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NEW CONTRIBUTIONS IN STEROL METABOLISM

By Professor RUDOLF SCHOENHEIMER

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IT is only a relatively short time since we assumed that plants only could synthesize complex compounds whereas animals were forced to obtain these complex compounds indirectly from plants and that in modifying these complex compounds for their specific needs only slight chemical changes are necessary.

One of the most complicated substances in the animal body is cholesterol. It is a hydroaromatic secondary alcohol with 27 carbon atoms containing two combined six carbon-rings, one five carbon-ring, a side chain and one double bond.

It is, therefore, not surprising that this knowledge of the constitution of cholesterol led to the assumption that the animal body was forced to obtain this or a similar substance from plants because we could not conceive of synthetic activities of that order in animal tissues. However, cholesterol-balance studies by various authors (Thannhauser, Bürger, Beumer, Randles and Knudson) indicated that at least under certain special conditions, animals also possess the power to form cholesterol because they sometimes found a negative balance in their metabolism studies, that is, they sometimes found more sterol excreted than consumed.

These observations left unanswered the question of whether all the cholesterol present in the animal body was due to a synthesis in the animal body or whether the major part did not after all come from vegetable food. The conversion of plant sterols into cholesterol in the animal body requires that the plant sterols which differ chemically from cholesterol must be absorbable, a question which up to the present has not been investigated in detail.

The only phase of sterol absorption in the animal body known up to the present time is that of the absorption of animal cholesterol. Considerable evidence in favor of this view had been accumulated.

[1] Alpha Omega Alpha lecture delivered in Cleveland, February 27, 1931. These studies were in part aided by a grant from the Douglas Smith Foundation for Medical Research, University of Chicago.

A somewhat crude but very significant observation in this connection is the so-called experimental atherosclerosis in rabbits. These animals which are accustomed to a purely vegetable diet are very sensitive to the addition of cholesterol to their diet, in that one observes after a certain experimental dietary period morphologically visible deposits of cholesterol and cholesterol esters in various organs and especially in the aorta, a change which presents a most remarkable resemblance to the human atherosclerosis. The aorta of the rabbit is especially sensitive toward the oral administration of cholesterol), because even the daily feeding of a few milligrams if continued over a longer time leads to such deposits (Anitschow).[2]

If the above referred to theory of the simple conversion of plant sterols into the animal cholesterol were correct every rabbit should show a marked atherosclerosis, because the quantity of plant sterols present in the usual feed of rabbits is approximately ten times as high as the dose of cholesterol which calls forth an atherosclerosis. It is, however, a fact that a true spontaneous atherosclerosis with deposition of cholesterol has never been observed in rabbits in spite of the most painstaking investigations. This difference between theory and fact lead to our investigations on plant sterols.

Although practically only one sterol is found in animal tissue we, nevertheless, find a great number of different sterols in plants; these usually occur in mixtures and are separated from each other with great difficulty. Cholesterol does not even occur in traces in plants. The most commonly occurring plant sterol, which is never absent in higher plants, is sitosterol which has the same elementary formula as cholesterol, has almost identical chemical properties and which, according to Windaus,[3] is a stereo-isomer of cholesterol.

Our first experiments were carried out with sitosterol, of which larger amounts were available. We have fed enormous doses of sitosterol over long periods to rabbits and other animals, which would have suffered most severe pathological changes if cholesterol had been given instead, but the animals remained healthy and showed not even the slightest change.[4] The chemical examination of these animals showed that they contained no more cholesterol than the normal ones while those fed on cholesterol contained approximately twice the amount. The blood cholesterol concentration which is very much increased by cholesterol feeding remained normal in the sitosterol fed animals throughout the entire period. We have, furthermore, separated the total sterols from animals which were kept for almost one year on the sitosterol containing diet and have examined these sterols by Böhmer's method for sitosterol, which would detect concentrations of about 2 per cent. sitosterol. However, no sitosterol was found.[5]

Furthermore, feeding experiments on rabbits with quantitative collection and analysis of the feces showed within the experimental errors of the method that the sitosterol fed is completely excreted in the feces while the food cholesterol is similarly recovered only to the extent of about 50 per cent.[6]

All these experiments made it appear probable that the plant sterols are not absorbable just as we had assumed, but it was by no means still impossible that they may have been absorbed, then rapidly changed to cholesterol but followed by a very rapid excretion so that we would not be able to find them in the animal tissues by our method. If this were the case one would have found in part cholesterol or one of its derivatives in the feces from the plant sterol fed animals, because plant sterols do not occur in animal tissues. We have, therefore, examined the excreta of various animals when kept on a purely herbivorous diet.[7] Rabbits were kept on the usual diet of hay and beets from which a well characterized sterol mixture could be separated. From the feces the same sterol mixture could be recovered, that is, this plant sterol mixture had passed through the alimentary tract without being altered qualitatively or quantitatively.

Later more exact studies were carried out which very specifically prove that plant sterols are non-absorbable.[8] A large part of the food, especially the fats and lipins, after absorption pass through the thoracic duct. When an absorbable sterol, such as cholesterol, is fed it can be found in large amounts in the thoracic duct lymph. The examination of the thoracic duct lymph during the absorption period, is, in spite of the experimental difficulties, nevertheless the most ideal and safest method for determining the absorbability or non-absorbability of a sterol. One adds to the sterol to be tested a definite amount of the easily absorbable cholesterol and then one attempts to determine quantitatively the cholesterol as well as the other sterol content in the thoracic duct lymph. The relative proportions of the two sterols found will indicate how much more difficultly the other sterol is absorbed. This method is, of course, applicable only to those substances which can be quantitatively determined in presence of cholesterol. Un-

[2] Anitschkow, *Virch Arch.*, 249, 73, 1924.

[3] Windaus and Rahlén, *Ztschr. Physiol. Chem.*, 101, 223, 1918.

[4] Schoenheimer and Yuasa, *Ztschr. Physiol. Chem.*, 180, 5, 1929.

[5] Schoenheimer, *Ztschr. Physiol. Chem.*, 180, 16, 1929.

[6] Schoenheimer, *Ztschr. Physiol. Chem.*, 180, 24, 1929.

[7] Schoenheimer, *Ztschr. Physiol. Chem.*, 180, 36, 1929.

[8] v. Behring and Schoenheimer, *Ztschr. Physiol. Chem.*, 192, 97, 1930.

fortunately this is not true in all cases. In such cases special methods had to be devised, the discussion of which I can not go into in this brief review.[9] Our lymph studies uniformly showed that we obtained only pure cholesterol in the lymph when a mixture of cholesterol and plant sterols was fed.

From these studies one can definitely conclude that plant sterols are non-absorbable and it is, therefore, not surprising that rabbits remain normal after being fed of these substances. The results, however, also lead to the conclusion that animals which live on plants only and therefore never consume the absorbable cholesterol, are forced to synthesize their entire cholesterol necessary for their tissues.[10] Similarly since the carnivorous animals receive cholesterol directly from their food and always in the last analysis from an herbivorous animal which synthesizes its own cholesterol, we can conclude that all cholesterol is a synthetic product produced in the animal body and that a sharp biological division exists in the sterols of the plant and animal kingdoms.

However, all these experiments involved the use of chemical methods which introduce slight experimental errors. For this reason, we could not exclude the possibility that we might, nevertheless, have absorbed and deposited the minutest traces of plant sterols which were not detectable by our methods.

This is further suggested by the fact that throughout the animal organism one always finds with the cholesterol a slight trace of ergosterol which, in spite of the very small amount present, is of great biological importance, because it assumes antirachitic activity after exposure to ultra-violet light. The ergosterol found in the animal body is regarded as a plant sterol and its occurrence in the animal organsim was explained on the assumption that it is absorbed from vegetable foods and then transported to the tissues.

We finally also investigated the behavior of ergosterol, mainly because its detection with the aid of its absorption spectrum and the biological method is 1,000 to 10,000 times more sensitive than that of the other plant sterols. In such a case even a very, very slight absorption would not escape detection. The optical determination of the preparations separated by us were very kindly carried out through the courtesy of Professor Windaus in Göttingen, who also aided us in many other phases of our work. We fed rats, mice and rabbits for a long period with perfectly pure ergosterol which was entirely free from the activated form and possessed no antirachitic action. The feeding as well as the isolation of the sterols was carried out in the dark. It was found that the ergosterol fed animals yielded body sterols with no higher content of ergosterol than those from the unfed animals.

The above is in the strictest sense not final evidence of the non-absorption because we obviously determined only the possible storage of ergosterol. For that reason, the thoracic lymph was examined also.[11] Dogs were given a fatty meal to which were added one gram pure ergosterol and one gram pure cholesterol. The cholesterol preparation separated from the lymph was found to contain less than 0.02 per cent. ergosterol, a concentration which is less than that found in most cholesterol preparations. If the cholesterol and ergosterol had been equally well absorbed, the cholesterol preparation obtained from the lymph should have had about 2,000 times the observed ergosterol content. This experiment hardly permits of any other interpretation than that unirradiated ergosterol is not absorbable and that the exceedingly low concentration of ergosterol found in the thoracic duct lymph must have originated from other sources since the thoracic duct carries fluids from other sources than the digestive chyle. To be sure our experiments are not absolutely fool proof. They show, however, that ergosterol is absorbed only very slightly, so slightly that the very sensitive method used does not detect it. One can, however, not exclude the possibility that vanishingly small but biologically important amounts of ergosterol may, nevertheless, be absorbed over a long time period. The question as to whether the animal body may also be able to synthesize its own ergosterol I shall discuss later.

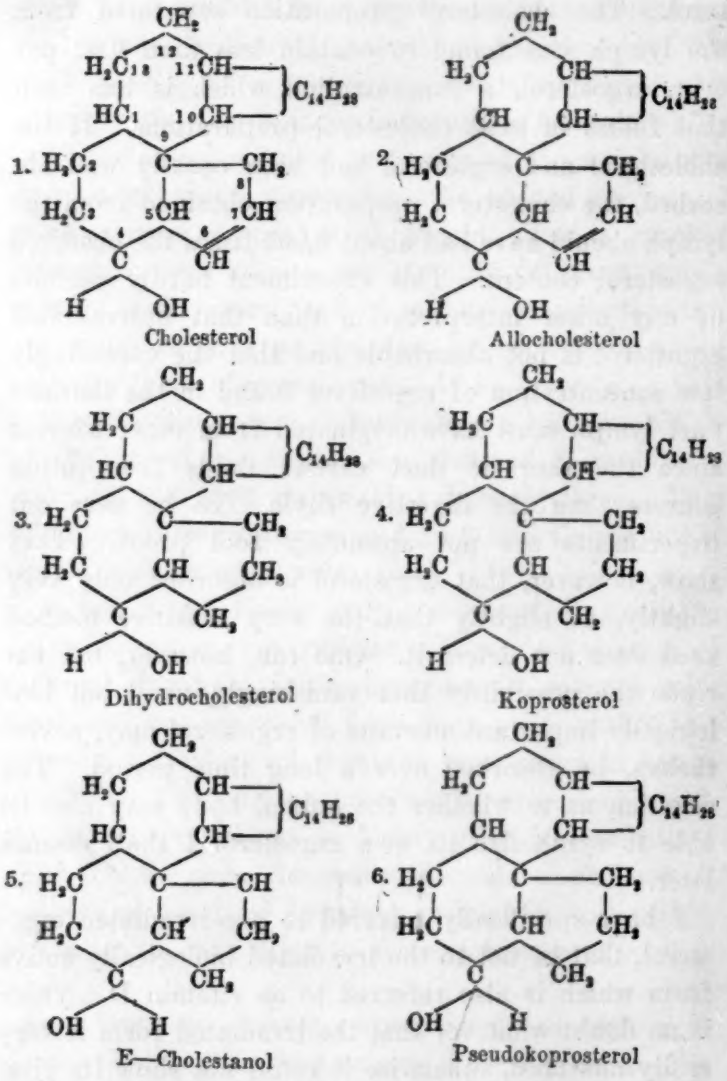
I have specifically referred to non-irradiated ergosterol, that is, not to the irradiated biologically active form which is also referred to as vitamin D. There is no doubt whatever that the irradiated form is very easily absorbed, otherwise it could not show its vitamin action and when fed in large doses even show toxic action. However, the irradiated ergosterol is a very different substance chemically from the non-irradiated form, in fact, we know that it is a stereoisomer. The fact that unirradiated ergosterol is absorbed with great difficulty or, not at all, while the irradiated form is very easily absorbed, leads to the same relationships as in the case of cholesterol and sitosterol which are also considered to be stereoisomers and where the one is easily absorbed and the other is not absorbable. In the course of our investigations we have thus opened up a field which shows that absorbability in the case of sterols is dependent upon chemical constitution and that even slight changes in the molecular structure are sufficient to

[9] Schoenheimer, v. Behring and Hummel, *Ztschr. Physiol. Chem.*, 192, 117, 1930.

[10] Schoenheimer, *Ztschr. Physiol. Chem.*, 185, 119, 1929.

[11] Schoenheimer and v. Behring, *Klin. Woch.*, 9, 1309, 1930.

render an absorbable substance completely non-absorbable. As a result, we have undertaken a systematic study involving experiments on derivatives of the easily absorbed cholesterol.[9] We studied only those substances in which only very slight changes in molecular structure are involved and in which the sterol character is still present, because we knew that even the slightest structural changes influenced absorbability.



The formulae above indicate the derivatives we have studied. In addition to cholesterol there occur in the animal body two derivatives; these occur in the feces and are sterols in which the unsaturated bond of cholesterol has been saturated by hydrogenation. These two substances, which I shall refer to again later, are koprosterol and dihydrocholesterol, two isomers which differ from each other only in a cis-trans-isomerism of carbon atom No. 1. The dihydrocholesterol is obtained directly from cholesterol by the addition of hydrogen while koprosterol is related to allocholesterol, in which the same isomerism exists with reference to carbon atom No. 1 and which was prepared only recently by Windaus. This substance is exceptionally labile in that it readily rearranges into cholesterol under the influence of heat or of dilute acids. For these reasons we must take into account in feeding experiments with allocholesterol the possibility of the acidity of the gastric contents converting a part thereof into cholesterol and thus rendering it absorbable. The comparative absorption studies on cholesterol and allocholesterol showed that the latter is absorbed much more difficultly than cholesterol (about one half to one third as much). It is, however, by no means impossible that the absorbed allocholesterol actually was first converted into cholesterol in the stomach.

The other derivatives of cholesterol, especially those which also occur in the organism and which can be separated in traces from cholesterol also were non-absorbable even in traces.

These observations then led to the conclusion that the organism behaves in an exceptionally specific manner in the absorption of the sterols. Even isomerism suffices to alter the absorbability and the saturation of the unsaturated bond changes the easily absorbable body to a completely unabsorbable form.

An absorption, which is so specifically dependent upon molecular structure, has previously not, to my knowledge, been systematically investigated. The observations led to an approach at interpreting the difficult or non-absorption of sitosterol and unirradiated ergosterol and the ease with which cholesterol and irradiated ergosterol pass through the intestinal wall.

We have also extended our investigations to the consideration of the waste products or, better stated, the products of intermediary metabolism of cholesterol, a field regarding which almost nothing was known up to the present. I pointed out that cholesterol does not appear as such in the feces but as the two saturated forms, koprosterol and dihydrocholesterol. The former of these occurs in far greater amounts.

The general view held up to the present as to the formation of these bodies was that the cholesterol from food, bile or digestive juices enters the intestines and is there converted into these products by the action of intestinal bacteria. We have here under consideration a reaction involving hydrogenation, that is, a reduction, a reaction long known to be easily produced by intestinal bacteria, as for instance the conversion of the unsaturated bilirubin into the saturated urobilin-like body. Although the conversion of bilirubin into urobilin has been successfully carried out *in vitro* by putrefactive organisms, all attempts by others as well as by us[12] with the *in vitro* conversion by bacteria of cholesterol into koprosterol and dihydrocholesterol have led to negative results.

In order to clarify the origin of these saturation sterols we undertook another method of attack. We, contrary to the earlier investigators, postulated that the saturated sterols did not originate in the intestines

[12] Schoenheimer, v. Behring, Hummel and Schindel, *Ztschr. Physiol. Chem.*, 192, 73, 1930.

but that they represent intermediate products of metabolism, that is, that they are formed in the tissues themselves and are excreted into the intestinal contents. For these studies it was necessary to develop a method which is sufficiently accurate to determine traces of these saturated sterols when mixed with cholesterol.[13] This method is based upon the observation that all sterols form difficultly soluble addition compounds with digitonin but that the bromine derivatives of the saturated sterols, that is the cholesterol dibromide which is easily and quantitatively obtained by treating a solution of the sterol with free bromine, are no longer precipitable by digitonin. Obviously one simply needs to treat the sterol mixture carefully with bromine and then the addition of digitonin precipitates only the saturated sterols originally present because the absence of the double bond prevents the formation of bromide derivatives of the saturated sterols.

With this method we could, to our surprise, establish the fact that all cholesterol preparations, immaterial from what animal or human organs they are obtained, contain such saturated sterols, usually small in amount.[14] In most cases not more than two to three per cent. is present, but none of the sterol preparations were found free from these substances. The fact that these substances are present in such small amounts explains why they were not detected before.

We succeeded in separating these saturated sterols in pure form by working with large quantities of the various cholesterol preparations.[15] We expected, of course, that we would find a mixture of a composition very similar to that found in feces, that is, a mixture of koprosterol and dihydrocholesterol with the former in great excess. Contrary to these expectations we found only pure dihydrocholesterol and no trace of koprosterol could be detected.

The same observations were made on plant sterols. All available plant sterol preparations contained in addition to the main component, the unsaturated sterols, varying amounts of saturated sterols. It appears, therefore, that the occurrence of sterols as mixtures of the saturated and unsaturated kinds is a common biological observation.

Naturally our first studies were on animals. Where do the saturated sterols originate? I have already stated that these substances which always occur in large amounts in the intestinal contents are non-absorbable and are not, as we assumed formed in the intestines by the action of bacteria on cholesterol. There is, therefore, no other explanation left for us than to state that the dihydrocholesterol is formed in the tissues by the hydrogenation of the cholesterol and that it is to be considered a product of cholesterol metabolism.

The real question next was by what path does dihydrocholesterol thus formed in the body pass into the intestines? Formerly it was assumed that the main part of the cholesterol from the body passed to the intestines by solution in the bile. Therefore, it was necessary to assume that very likely gall stone cholesterol would also contain very large amounts of dihydrocholesterol. We found, however, only very small amounts. The calculations then indicated that still another source must exist. Sperry[16] some time ago showed that the intestinal wall is permeable to lipoids and that we have excreted with them some cholesterol. We, therefore, suspected that the sterol thus excreted probably was not cholesterol at all, but dihydrocholesterol instead.

In order to prove this we found it necessary to carry through the isolation of sterols from large amounts of sterile intestinal secretion, an undertaking which presented tremendous experimental difficulties. The following procedure was found satisfactory.[17] We sectioned the small intestine of a dog above the large intestine and sewed the lower end of the small intestine to an opening in the abdominal wall. The isolated end of the intestine which was still united to the anus was rinsed with many liters of water until the washings were obtained perfectly clear, then the upper end of this intestinal section was lighted. The blind intestinal section thus consisted of the large intestine and a small part of the small intestine and still connected to the anus. After two days this intestinal preparation was rinsed daily from the anus with warm water. After about eight days of such treatment the rinsings from this intestinal preparation were found almost sterile. If the anus was now closed by operative procedure the antibacterial action of the intestine was sufficient to destroy the remaining microorganisms.

After one to two months the animal was sacrificed and the contents of the intestinal preparation recovered. The content was very interesting. In most cases it was completely sterile. Usually we obtained per day 60 to 70 grams of a light yellow, wax-like mass, the surface of which presented in relief the character of the mucous membrane of the intestine. We have no doubt that we have here the normal dried intestinal secretion which normally would be mixed with the feces and therefore would escape detection. It has only a small water content and all reabsorbable substances, including cholesterol, must have been reabsorbed, that is, we have here those substances which

[13] Schoenheimer, *Ztschr. Physiol. Chem.*, 192, 77, 1930.
[14] Schoenheimer, v. Behring and Hummel, *Ztschr. Physiol. Chem.*, 192, 93, 1930.
[15] Schoenheimer, *Ztschr. Physiol. Chem.*, 192, 86, 1930.
[16] Sperry, *Jl. Biol. Chem.*, 82, 560, 1929; *ibid.*, 85, 455, 1930.
[17] Schoenheimer and v. Behring, *Ztschr. Physiol. Chem.*, 192, 102, 1930.

are secreted but not reabsorbed. From these masses of material we could separate very significant amounts of dihydrocholesterol, but koprosterol was not found.

As a result of these observations we had proved that the dihydrocholesterol after its formation in the tissues actually is secreted through the intestinal wall. This clarifies the metabolism of dihydrocholesterol but not of koprosterol. Since koprosterol was not found in the tissues but always in larger amounts in the feces, we must still assume that it is a product of the bacterial action in the intestines even though we have not been able to reproduce the same *in vitro*. We must consider that up to the present it has not been possible to cultivate all of the intestinal bacteria and it is very probable that any one of the difficultly cultivatable anaerobes may be able to bring about this change. It is hoped that the near future may throw light on this question.

To us the most important question now appeared to be, what is the significance of this intermediary hydrogenation which leads to the formation of dihydrocholesterol in the animal? The question may also be formulated to read: What is the source of the hydrogen which leads to the hydrogenation of the double bond in cholesterol? In view of this process existing in both animals and plants we must conclude that we have under consideration a general biological process in which the cholesterol functions as hydrogen acceptor. According to the Wieland dehydrogenation theory, it was necessary to assume that this hydrogen originated from other organic substances which yield hydrogen and thus became unsaturated. This hydrogen yielding substance was expected to be found among the other lipoids associated with which cholesterol occurs in nature.

Since the amount of dihydrocholesterol formed daily is very small, a working hypothesis was advanced that the formation of dihydrocholesterol is associated with the formation of fat soluble, highly unsaturated, but biologically very active substance. Such a substance, for example, would be ergosterol which possesses a structure very similar to cholesterol, but which has three double bonds instead of one as in cholesterol. I stated that ergosterol is very difficultly, if at all, absorbable and since it is present in all animal tissues it led to the view that animals as well as plants possess the power of forming the ergosterol. If this is the case, then it is also possible that we might have formed simultaneously from cholesterol both dihydrocholesterol and an ergosterol-like body.

Recently Koch, Koch and Kraus-Ragins,[18] carried out a very illuminating experiment. When cholesterol, freed from the last traces of ergosterol, was heated at a high temperature without access to oxygen, a new substance was obtained which, after irradiation by ultra-violet light, possesses antirachitic activity.

We have modified these experiments for our purposes and have worked with cholesterol preparations which were not only free from the last traces of ergosterol but also of dihydrocholesterol.[19] When these preparations were heated to high temperatures in a high vacuum with a complete exclusion of oxygen there was obtained a small amount of a saturated sterol which very likely is dihydrocholesterol. At the present time we have only a very small amount of this difficultly obtainable substance, so that we have not been able to identify it accurately. The formation of this saturated sterol and of the antirachitic body can, however, not be explained in any other way than to suppose that a small part of the cholesterol has been converted by dehydrogenation into an ergosterol-like body with the probable introduction of two new double bonds and that at the same time there is formed in another part of the cholesterol a completely saturated sterol due to the liberated hydrogen.

We have not always succeeded in carrying out this reaction because it appears that a catalytic agent may be involved. This reaction makes it appear very probable that the animal body may also be able to carry out a similar process and that the dihydrocholesterol found by us is in fact associated with the formation of the ergosterol. This interpretation must, however, be confirmed by further experimentation.

In this lecture I have referred only to the most obvious results of our work. On account of lack of time I have unfortunately not been able to discuss the methods which are so very important in all experimental work and serve as a basis for a critical evaluation.

NATIONAL PARKS IN AFRICA

THE EXTENSION OF WILD-LIFE CONSERVATION

By MARY L. JOBE AKELEY, A.M., Litt.D.

SECRETARY OF THE AMERICAN COMMITTEE FOR THE PARC NATIONAL ALBERT

THE first national park created in the great continent of Africa is the Parc National Albert, established by royal decree of Albert, king of the Belgians, in 1925. Here, in the Kivu District of the Belgian Congo, are found the rare mountain gorilla (*gorilla gorilla berengei*), to-day of increasing scientific importance. Living side by side with the gorilla on the

[18] Koch, Koch and Kraus-Ragins, *Jl. Biol. Chem.*, 85, 102, 1929.

[19] Schoenheimer, *Naturwissenschaften*, 18, 881, 1930.

cool wooded slopes of the extinct volcanoes, Mikeno, Karisimbi and Bishoke, are leopard, elephant and buffalo. Pygmies, still primitive and unspoiled by the white man, dwell in the lower reaches of the gorilla forest. Along the shores of Lake Edward and on the nearby sandy plains (areas added in 1929), are herds of antelope such as are found in British East Africa. Great herds of hippo frequent not only Lake Edward but also the slow-flowing Rutshuru River. Now that this first national park has become a reality, Belgian conservationists are planning to increase their sanctuaries for conservation and research in the Belgian Congo. Parc National Albert will be followed by two new Congo park projects, Parc Leopold and Parc Ruwenzori.

Immediately after his 1921–22 expedition for the American Museum of Natural History, the naturalist and conservationist, Carl Akeley, called the attention of scientists as well as of nature lovers to this remote and beautiful part of the world. While securing there a group of gorillas for a natural history exhibit for African Hall, he was unwilling to take any life needlessly. He collected only five—one half the number of specimens permitted him by the Belgian Government—because he believed this number sufficient to serve his scientific purpose. While observing the gorillas at close range, he became impressed by the non-combative nature of these animals when undisturbed by man. He also was greatly surprised by the small number of gorillas inhabiting the forests of the extinct volcanoes, Mikeno, Karisimbi and Bishoke, in which they had been reputed to be plentiful. He knew that many "mighty hunters" of big game were at that time eager to hunt and kill gorillas in order to have a new sport and new trophies. Since he believed it would be an easy matter to exterminate the whole colony because of the nature of the gorilla and because of the scarcity of the animal, he began to advocate a gorilla sanctuary for the protection of the great ape as well as of all other wild life, both plant and animal. Of the greatest importance to his project were Mr. James Gustavus Whiteley, Belgian consul general at Baltimore, and Dr. John C. Merriam, president of the Carnegie Institution of Washington, who recommended this gorilla sanctuary plan to Baron Emile de Cartier de Marchienne, then Belgian ambassador to the United States. The ambassador took it directly to King Albert, who was so impressed by the desirability of the measures advocated that he created the Parc National Albert in 1925.

Shortly after the Parc was established, my husband requested Belgian permission, through Baron de Cartier, to return to the Congo. To secure studies for a painted background and accessories for the Gorilla Group and to carry on initial investigations of the gorilla in his native haunt were the objects of our 1926 expedition to the Kivu—the Akeley-Eastman-Pomeroy African Expedition for the American Museum of Natural History. On our way to Africa in February, 1926, my husband and I went to Brussels, where we were entrusted with the royal mission to the Kivu, which empowered us to execute a general survey of the new national park. Later we invited Dr. J. M. Derscheid, zoologist and cartographer of Brussels, to join us in Africa to assist with this survey. After my husband was called to the Great Beyond, three days after we reached his 1921 camp in the gorilla forest, Dr. Derscheid rendered invaluable service to our expedition so that we fulfilled the Belgian royal mission. On my return to Europe, I was requested by King Albert to give him personally a preliminary account of the results of our expedition. In Brussels in 1928, Dr. Derscheid and I prepared our report and our recommendations for the Belgian Government concerning the future of the Parc National Albert. According to the original decree, the park was limited to a triangular area comprising the three extinct volcanoes, Mikeno, Karisimbi and Bishoke. We now proposed that this area be extended so as to include Nyamlagira and Nyiragongo, active volcanoes of importance to geologists and seismologists; that it should include the southern shore of Lake Edward and the Rutshuru River, where animal life is abundant; that certain native villages and arable lands be excluded in order to avoid any future conflict between native rights and the economic development of the country on the one hand and the interests of science on the other; and, for the promotion of scientific research, that there should be established a central station for research and administration, including laboratories, library and study museum, and also that ranger stations should be built throughout the park. In conclusion, we recommended that the management of the park be placed in the hands of a scientific institution so favorably situated as to obtain financial and scientific help both in Belgium and in foreign countries.

King Albert received us at the Royal Palace on October 8, 1928. There, our report was submitted and throughout a long and interesting evening the future of the park was discussed. Subsequently, the royal decree of May 6, 1929, increased the park domain to 500,000 acres, according to our proposals, and provided therein for the preservation of all fauna and flora for strictly scientific purposes. The decree also stipulated that the park is to be administered by the *Commission du Parc National Albert* and by a committee of direction. His Highness Prince Eugene de Ligne was named president. In the park, it is forbidden, under penalty of penal servitude, or fine, or both, to pursue, capture, kill or molest in any way any kind of wild animal, including animals which are

reputed harmful; to take or destroy the eggs of wild birds; to cut down, destroy or remove any uncultivated plant; or to make any excavation, embankment, boring or any operation of a nature to change the aspect of the ground or of the vegetation. Unless provided with a special permit, no one (except officials and others properly qualified) may enter the park, or circulate, camp or sojourn therein, or introduce dogs, traps or firearms, or possess or transport or export skins or other parts of wild animals, or uncultivated vegetable products. Lands now occupied by natives or private persons are to be expropriated. Even on these tracts under private or native occupation, the destruction, capture or pursuit of the gorilla as well as all forms of hunting this animal are absolutely forbidden.

Around the park proper is a zone of protection. In it cutting down trees, hunting and fishing are prohibited. The few natives who live therein will not lose their hereditary rights, but they may employ only their primitive weapons. The Belgian Government will pay the strictly administrative expenses of the park, maintaining a corps of conservators and native police.

In October, 1929, King Albert formally installed the *Commission du Parc National Albert,* a body of eighteen scientists chosen from England, Sweden, the United States, France, the Netherlands and Belgium. In his address at the *Palais des Académies,* Brussels, His Majesty described the park as unique because of its widely diversified scientific opportunities. He emphasized the varied aspects of the region, "which are of interest not only to geologists and mineralogists, but which are remarkable from the point of view of ethnography as well, since Bantu and Hamitic tribes as well as pygmies (Batwa) are simultaneously present."

In 1930, the American Committee for the Parc National Albert was formed to cooperate with the International Committee in the matter of scientific research. His Highness, Prince Albert de Ligne, at that time Belgian ambassador at Washington, who from the beginning has been most active in forwarding the plans for the park, was named by His Majesty chairman of the American Committee; Mary L. Jobe Akeley was appointed secretary. In addition to the two American members of the International Commission, Professor Henry Fairfield Osborn and Dr. John C. Merriam, the Prince de Ligne subsequently appointed as members of the committee Mr. Stanley Field, president of the Field Museum of Natural History, Chicago; Dr. Vernon L. Kellogg, of the National Research Council, Washington; Dr. Robert M. Yerkes, of Yale University; Dr. George W. Crile, of Cleveland; Dr. Lewis H. Weed, of Johns Hopkins University, Baltimore, and the Hon. James Gustavus Whiteley, Belgian consul general at Baltimore.

At a meeting of this committee, in December, 1930, at the American Museum of Natural History, New York, the Prince de Ligne, who was leaving America shortly thereafter to take up his duties as Belgian ambassador at Rome, resigned his office. Dr. Merriam was elected president to succeed him. At this time, it was decided to enlarge the American committee in order to afford a national representation. Subsequently Senator Frederic C. Walcott and Mr. George D. Pratt were elected as new members, and more recently, Dr. William K. Gregory, of Columbia University. The committee's purpose now is to bring the Parc National Albert and other similar undertakings in Belgian Africa in closer contact with American scientific and conservation organizations, as well as to secure support for these projects.

Dr. J. M. Derscheid, now *administrateur-général* of the park, present at this meeting, reported the progress of the Kivu park as well as detailed plans for the further extension of the park system in Belgian Africa. The newly projected Parc Leopold, near the northern border of the Congo, will comprise an area of 1,000,000 acres. Lying north and east of the Parc National Albert will be another new park, Parc Ruwenzori, adjoining the Belgian Congo-British Uganda boundary. The Congo park areas will thus total 2,000,000 acres.

Pending the official establishment of these new parks, activity has been concentrated in the Parc National Albert. Patrols of native scouts are on guard to prevent the killing of any wild animal and the destruction of plant life. Meanwhile the Belgian Government has appropriated funds for the maintenance of the park service, and has advanced a loan of two million francs, to begin immediate construction of a central station for scientific research. This station will be erected on a grant of twenty acres in the heart of the government post at Rutshuru. Here will be the central library, containing a collection of all the scientific treatises relating to the fauna, flora and geology of Central Africa; a study museum, for which will be collected all the animals indigenous to the immediate vicinity; laboratories, equipped for the use of zoologists, botanists, seismologists and geologists. Provision is being made for a chemical laboratory and a photographic wing. Nearby will be an assembly hall, administrative offices and living quarters. All these buildings are designed for the use of white men unaccustomed to the tropics. Although only one degree from the equator, Rutshuru is white man's country because its 5,000 foot elevation lifts it out of the torrid zone.

This central station, moreover, is now connected

with the outside world by a motor road to the Upper White Nile by way of Beni and Irumu—and thence by water and rail to the Mediterranean. Another road will soon connect with Kisumu, Uganda, and thence by train to Mombasa, the port of entry to Kenya Colony on the Indian Ocean. However, avenues of easy approach to this region will by no means result in letting down the barriers into the park so far as the outside world is concerned. One of the most important points in the scientific creed of the park is that therein the primitive shall be preserved! In addition to the general policy of absolute protection, certain designated areas will be kept wholly free from human intrusion, except as an emergency may demand.

Of especial significance in connection with international effort for immediate conservation are two recent addresses delivered in London—one by Major R. W. G. Hingston before the Royal Geographical Society on March 9, 1931, the other by Sir Peter Chalmers Mitchell on September 24, 1931.

Major Hingston recently returned from an African expedition which was approved by the Secretary of State for the Colonies and the Joint East African Board and at the request of the Society for the Preservation of the Fauna of the Empire. After visiting Northern Rhodesia, Nyasaland, Tanganyika, Kenya and Uganda, he has prepared a scheme for ten British national parks for Africa. He says:

> Of all the assemblages of wild animal life that of Africa is by far the most important. In the abundance and variety of its constituents, in the immense size, the unique character, and what we must call the prehistoric appearance of its examples there is nothing to compare with it in any other continent. The elephant, rhinoceros, hippopotamus, giraffe, okapi, gorilla are perhaps the most impressive manifestations of the creative force that to-day exist on the earth. Fortunately it is an expression of general feeling that the final extinction of these extraordinary creatures would be a gigantic calamity. Nevertheless it is equally true that these and many other types of the African fauna can not under existing conditions hope to survive far into the future. It is as certain as night follows day that unless vigorous and adequate precautions be taken several of the largest mammals of Africa will within the next two or three decades become totally extinct. Should that occur then assuredly we shall have abused a trust and future generations will judge us accordingly.
>
> Every large animal of whose extinction we have any record has been eradicated by human agency. Confining ourselves to the African fauna, the great blaubok, which inhabitated Cape Colony, was annihilated by the farmers in the year 1800; the quagga, which covered the plains of South Africa, was exterminated by the Boers in 1858; the typical form of Burchell's zebra, which existed in British Bechuanaland, became extinct about the year 1910. Certain other species have been so reduced that they may be said to border on extinction. Take for instance the white rhinoceros. Within the lifetime of many of us still living the white rhinoceros abounded in the African continent from the Vaal to the Zambezi. To-day it is reduced to twenty individuals in Zululand and one hundred and thirty individuals along the upper reaches of the Nile. It has been exterminated over half a continent within a space of fifty years. The gorilla, nyala, Grevy's zebra are species which have shrunk to minute numbers and are on the verge of disappearance. The whole African fauna is steadily failing before the forces of destruction brought to bear against it. Great and small, everything is retreating. And the saddest aspect of the melancholy picture is that it is the largest and most extraordinary examples which are yielding most rapidly in the conflict. I doubt if any of the great pachyderms, the elephant, rhinoceros, and hippopotamus, will, if present conditions continue, survive beyond the next fifty years.

He enumerates the four forces causing the annihilation of wild life: (1) The spread of cultivation; (2) the demands of trade; (3) the activities of sportsmen; (4) the menace of disease.

Stating that the weak point of the game reserve is its insecurity and want of permanence, he continues:

> The national park, in contradistinction to the Reserve, is placed by legislation on a more stable basis. It possesses a title. It is made by Act of Parliament the property of the public forever to be utilized for the sole purpose of preserving the natural subjects within it. It can not be abolished or altered in any way except by subsequent Act of Parliament. This is the most secure and rigid status that can be given to a wild-life sanctuary. It alone offers any reasonable hope that the sanctuary may last into the distant future.
>
> There are only two institutions in Africa which at present possess that likelihood of permanency implied in the status of a national park. One is the Kruger National Park of the Transvaal, established in the year 1926. The other is the Parc National Albert of the Belgian Congo, established in the year 1925. Both of these have some reasonable prospect of surviving the economic importunities of civilization. It is the belief of all who desire the perpetuation of the fauna that national parks on this rigid basis should replace the fluent reserves.

For the address of Sir Peter Chalmers Mitchell, I quote from an extract published by the London *Times* of September 25, 1931. The great naturalist reviewed the dangers threatening wild life in every part of the world, and which were increasing with the improvement of transport. "In most countries," he said, "the conscience of the people and of governments is being awakened to the danger, and much is being done, by game laws, the institution of closed times and the making of reserves. Unfortunately these measures are insufficient, and, as he had urged in an address to the British Association in 1912, it is of vital importance that large areas should be set apart for all time, secured against the sportsman and settler and pros-

pector, preferably under international sanction, for the perpetual preservation of the plants and animals and natural beauties they contained. Since 1912 there has been a number of additions, of which the most important are the Kruger National Park, made by the Union Government of South Africa, and the Parc National Albert in the highlands of the Belgian Congo."

"The latter, both from its natural beauty and the animals it contained, he characterized as one of the most interesting in the world. Among other animals it contains some of the few surviving gorillas in the natural surroundings which they have occupied for hundreds of thousands, possibly for millions of years. Across the frontier in Uganda, in territory under British control, there is an area of a few square miles of exactly the same physical features, and occupied either permanently or occasionally by gorillas of the same variety. For several years the Zoological Society of London, the Society for the Preservation of the Fauna of the Empire and other bodies and individuals have urged the Colonial Office to place this area on exactly the same terms of permanent security as the Parc National Albert. The governor of Uganda has declared himself in favor of the proposal, and the Government of Belgium, through the ambassador in London, has begged that this should be done. But the Colonial Office has remained apathetic or obdurate, putting off the decision on one ground or another. It is much to be hoped that this blot may be removed from the reputation of Great Britain."

Obviously the future is full of difficulty and fraught with the gravest danger to wild life, but active effort among scientific men in both Europe and America will undoubtedly advance the movement for permanent conservation under fundamental law. Moreover, the preservation in certain areas of the primitive, wholly unaffected by the aggressive march of civilization, offers a rare scientific opportunity. To accomplish this is now the spirit motivating many who now carry on the fight to save vanishing Africa. Theirs is not a sentimental interest. It is a true understanding and a realization of the urgent need for action. In Africa, at least, Carl Akeley's dream, now become a reality, has halted the juggernaut of mass destruction. Belgium's whole-hearted action is epoch-making in the international possibilities of conservation and of scientific inquiry. Such liberal and broad-minded policy will go far toward influencing other nations and cementing national friendships.

Because the Parc National Albert offers an unparalleled opportunity for scientific investigation it is confidently hoped that interested laymen in America as well as elsewhere may forward the effort for the great central scientific station in the Belgian Congo Park. Practical and sympathetic support will become not only a force contributing to the advancement of science, but it will be of material assistance in the fight for the conservation of wild life under conditions of unusual significance.

SCIENTIFIC EVENTS

DANIEL GABRIEL FAHRENHEIT

DANIEL GABRIEL FAHRENHEIT, inventor of the mercury thermometer, was a native of Danzig. There is some ground for suspecting that the family may have come originally from Königsberg, in East Prussia. At any rate, numerous persons bearing this and similar names have been located there. The letter printed below is translated from the German original, which is to be found in the town archives of Danzig. It was called to the writer's attention by Dr. Recke, the chief archivist of Danzig, who kindly consented to its publication in English. Dr. Recke planned to publish it in its original form in the course of the present year (1931) in the *Zeitschrift des Westpreussischen Geschichtsvereins*. The scheme of Fahrenheit's guardians to have their energetic young ward—then about twenty-one years of age—sent to the most remote of Dutch colonies did not materialize. Except for occasional travels abroad, Fahrenheit remained in Amsterdam and The Hague until his death in 1736, and won his claim to fame in his adopted country. He appears to have begun the use of mercury for thermometers in 1720, and he reported his invention to the Philosophical Society of London in 1724. It may be of interest to note that whereas his own explanation was that he determined his zero point by the behavior of a combination of salt, ice and sal ammoniac, some German authorities insist that Fahrenheit's zero represents nothing else than the coldest day in Danzig in 1709! All accounts agree that the winter of that year was exceptionally cold. If the latter view is valid, this troublesome son of the Free City provides a curious link between Danzig—at its coldest—and that Anglo-Saxon world that has so persistently gauged its temperature by his device.

Mr. Burgomaster and honorable gentlemen [*of the Danzig Town Council*]*:*

We, who have been named as the guardians of the minor children of the late Daniel Fahrenheit, have sent his son, Daniel Gabriel, a minor, to Amsterdam by his own consent, to serve in an office, in the hope that he would learn there to conduct himself properly. But things have gone very badly with this minor; he has spent the money given him; and he has behaved himself regrettably in other ways. So, in order to protect the interests of his brothers and sisters, we have been obliged

to sequester a part of his capital, and have requested him through his patron to turn a new leaf. But he has paid no heed, he has resumed his former practices, so we have been put to not a little trouble and pains to try to bring about a change for the better in his mode of life, but without being able to do anything with him. We have finally, on his own representation, decided to have him sent to the East Indies, for which purpose we dispatched him to Amsterdam a few weeks ago, and sent orders to a certain merchant [firm] by the name of Johannes Droogenhorst and Son to help him to a place with the East India Company, which was done. But when the time came for him to present himself, he failed to appear, and according to a report that has come in, he has gone to the bad again and resumed his former way of life. Because we can see nothing ahead for him except destruction and dire ruin to his temporal well-being, we guardians desire to report the situation to the honorable Council, as his supreme guardians, hoping that the Council with the help and advice of the authorities will support this modest expression of our opinion, and request (though we would not go contrary to the wishes of the honorable Council) that we be authorized to send full powers issued under the seal of the town to the said Droogenhorst and Son in Amsterdam, instructing them to locate him with the help of the authorities, place him under arrest, and send him to an appropriate place in the East Indies at the earliest opportunity. In laying the matter before your honorable Council, we seek only the welfare of this minor, his present and eternal happiness, await a happy decision, and remain

Your honorable Body's dutiful servants

[signed] BRUNO PLANDERS
BENJAMIN HEDDING
DANIEL NUTZMANN

Authorized guardians of the minor son of the late Daniel Fahrenheit, who is called Daniel Gabriel.

[Endorsement]: Read in the Senate [of Danzig] January 21, 1707. The Council authorizes the guardians to send a full power to the person [*i.e.*, firm] mentioned in the petition through the Chancery here.

WALDEMAR WESTERGAARD
UNIVERSITY OF CALIFORNIA
AT LOS ANGELES

FIELD EXPEDITIONS OF THE ORIENTAL INSTITUTE OF THE UNIVERSITY OF CHICAGO

THE twelve field expeditions of the Oriental Institute of the University of Chicago follow a line of great ancient cities, Persepolis, Babylon, Bagdad, Nineveh, Aleppo, Megiddo and Jerusalem, Cairo and Luxor, through the Highland Zone, the Fertile Crescent and the Nile Valley, at strategic sites in the area where civilization first arose.

Their work is as follows:

The *Megiddo Expedition* is excavating the mound of Armageddon or Megiddo in Palestine, commanding the most famous battlefield of the ancient world. The mound covers a stratified series of cities, which are now being laid bare. The work is in charge of Mr. P. L. O. Guy.

The *Anatolian Expedition* is working in the eastern part of Anatolia, has surveyed the country of the ancient Hittites, and has done considerable excavating in a mound at Alishar. Dr. H. H. von der Osten is in charge of the field work.

The *Iraq Expedition* is engaged in a ten years' program of excavation in Assyria and Babylonia. Last year Prof. Edward Chiera excavated the Temple of Sargon II and discovered the temple of Sennacherib near Khorsabad, north of Bagdad. Dr. Chiera is to take charge of the Assyrian dictionary, and Dr. Henri Frankfort is now field director.

The *Persian Expedition* is under the direction of Dr. Ernst Herzfeld. A party is working on the ruined palaces of the emperors Darius and Xerxes at Persepolis. This is the first American scientific mission in Persia.

The *Syrian Expedition* is excavating a mound believed to be that of the ancient city of Calneh, referred to by the prophets Amos and Isaiah.

In Egypt: Architectural Survey. Located at the Great Temple of Medinet Habu, built by Ramses III (1200 B. C.) at ancient Thebes, opposite modern Luxor in Egypt. This expedition is in charge of Professor Uvo Hoelscher.

Epigraphic Survey. Also at Medinet Habu; under the direction of Professor Harold H. Nelson. It is preserving the inscriptions on the walls of the temple, which were perishing, by a process requiring photographers, artists and epigraphers, who produce a perfect facsimile. These records are to be published in six large volumes and distributed throughout the libraries of the world.

Abydos Expedition. Here the institute is saving the records of the beautiful temple of Seti I, the reliefs of which are among the finest works of art surviving from ancient times. Headquarters of these three Egyptian expeditions are in Chicago House near Luxor, funds for which were contributed by Mr. Julius Rosenwald and the International Education Board.

Coffin Texts Project. This is located at Cairo. Dr. Alan H. Gardiner, research professor of the University of London, and Dr. A. DeBuck, have virtually completed the task of copying the texts, which were written with pen and ink on the inner surfaces of the wooden coffins in Egyptian burials, beginning as far back as the twenty-third century B. C. and coming down to the eighteenth century B. C.

Sakkara Project. The institute will publish some five folio volumes of colored relief paintings from the great masonry tombs of the cemetery of ancient Memphis, fourteen miles from Cairo. The copying is being done under the direction of Professor Prentice Duell.

Theban Tomb Paintings Project. Under the general direction of Dr. Gardiner, Mrs. N. DeG. Davis has long been engaged in copying the paintings on the walls of the tombs in the cemetery at Thebes. These will also be published by the institute.

Prehistoric Survey. This expedition is studying the prehistoric background of early civilization in Egypt and Asia Minor, and has carried on investigations of the geology of the Nile Valley. The field director is Dr. K. S. Sandford.

THE SIXTH INTERNATIONAL CONGRESS OF GENETICS

DURING the past few weeks there has been agitation on the part of certain individuals in favor of postponing the Sixth International Congress of Genetics. The council of that organization has been in prolonged and careful consultation on this matter and has decided that the congress should not be postponed.

In coming to this decision the council has been particularly influenced by several important factors. Among these may be listed the fact that in spite of adverse economic conditions a number of prominent foreign geneticists have already indicated their intention of attending the congress; a large number of lectureships which are available in American universities will undoubtedly provide honoraria for further foreign attendance; obligations already undertaken and commitments made to members and others interested; the distinct uncertainty of any marked improvement in the economic situation within any possible period of postponement; the already keen interest in the congress expressed by the great majority of American geneticists, and the inadvisability of postponing any international congress for reasons other than general war conditions.

Now that the matter of postponement has been carefully considered and finally settled, it should be the welcome duty of all American geneticists and interested biologists to make even more than ordinary effort to cooperate in organizing and carrying through a successful congress. As stated above, there is no doubt but that this result will be accomplished. The object in making this statement is simply to settle the question in the minds of all interested.

C. C. LITTLE,
Secretary General

RESEARCH EXHIBITS OF THE AMERICAN ASSOCIATION AT NEW ORLEANS

THE American Association for the Advancement of Science is again offering the facilities of its annual meeting for holding exhibits in science. The City of New Orleans has generously provided the exhibit space in its large Auditorium for non-commercial exhibits, on condition that these exhibits shall be open to the public. This exhibit space is provided with direct and alternating current, water and gas, and should therefore facilitate the setting up of active demonstrations both in pure and applied science. It is recognized that the progress in science is contingent upon the advance in material quite as much as the advance in the efficiency of warfare. Moreover, the growing economic support of science is contingent upon a broad public appreciation of its value. The continued improvement in the quality of the army of workers is none the less dependent upon the general popular appraisal. The council of the association believes that this public appreciation can be wisely augmented by objective presentations of the current works of scientific men and that willingness to exhibit may be taken as a democratic gesture on their part. These exhibits have the hearty support of the press service of this association, of which Austin H. Clark is chairman, as well as of Science Service, Howard Blakeslee, science editor of the Associated Press, and the other science editors. Experience has taught these men the advantages of the objective approach to sympathetic understanding of the public at large.

The exhibition of science at New Orleans, from December 28 to January 2, is an assured success in spite of the economic conditions and the resultant lateness in getting the organization for exhibition into operation. Among the exhibitors who already have their work prepared are the Bureau of Standards, the Bureau of Mines, the scientific bureaus of the Department of Agriculture, the Coast and Geodetic Survey, the U. S. Public Health Service, the Corps of Engineers, U. S. Army, the U. S. Geological Survey, the Carnegie Institution of Washington, the Science Department of the "Century of Progress," Tulane University Museum and the Tulane Department of Geology, the American Institute of New York, the American Museum of Natural History, the School Nature League, the Rice Institute, Forest Products Laboratory, New York Botanical Garden, Southern Forest Experiment Station, Stanford University, George Washington University, the Entomological Society of America, the American Association of Economic Entomologists, the Society of Petroleum Geophysicists, the American Association of Physics Teachers, Professor Burton E. Livingston, of the Johns Hopkins University, Professor Fred Allison, of Alabama Polytechnic Institute, Dr. Sam F. Trelease, of Columbia University, and Dr. John W. Shive, of the New Jersey Agricultural Experiment Station.

The Association is providing tables and wall space and supervision of the exhibits. Those desiring to exhibit should communicate immediately with Dr. F. C. Brown, chairman of the committee, at the office of the permanent secretary, Smithsonian Institution Building, Washington, D. C.

SCIENTIFIC NOTES AND NEWS

THE election of Dr. Vernon Kellogg as secretary emeritus of the National Research Council was announced by the executive board on December 9 following his resignation as permanent secretary, an office that he has held for the past twelve years from the time that the National Research Council began its activities on a peace-time basis. Dr. Kellogg's resignation is effective on December 31. The new position continues his work and affiliation with the National Research Council in an advisory capacity while he is relieved of administrative duties which his health does not permit him to perform.

DR. HENRY NORRIS RUSSELL, professor of astronomy at Princeton University and director of the Princeton Observatory, was elected president of the American Philosophical Society at its meeting on December 4. The election was to fill the vacancy caused by the death of Dr. F. X. Dercum.

CHIEF JUSTICE HUGHES, chancellor of the Board of Regents of the Smithsonian Institution, will present on December 18 two awards of $2,500 each, given by the Research Corporation of New York to Dr. Andrew Ellicott Douglass, of Tucson, Arizona, and to Dr. Ernst Antevs. The prize is awarded to Dr. Douglass for his researches on the rings that mark the annual growth of trees which have thrown light on the past climate of the earth and on the correspondence between weather and solar activity. The award to Dr. Antevs was in recognition of his use of varves, layers of clay in ancient lake beds, as timepieces of glacial activity. Dr. Douglass and Dr. Antevs will each give a half-hour illustrated account of his principal researches.

GOLD medals of the Radiological Society of North America were presented at the recent St. Louis meeting to Dr. Max J. Hubeny, of Chicago, for distinguished services in x-rays and radium, and to Dr. Carlos Heuser, of Buenos Ayres, for x-ray developments useful for studying the internal organs of women.

PROFESSOR J. STANLEY GARDINER, of the University of Cambridge, has been elected an honorary member of the Boston Society of Natural History.

THE German Society for Cancer Research has elected Dr. Frederick L. Hoffman, of Wellesley Hills, Massachusetts, to honorary membership in appreciation of his numerous contributions to cancer statistics research.

A DINNER was given in New York on December 2 by the American Society of Mechanical Engineers in honor of Dr. Calvin W. Rice, secretary of the society for the past twenty-five years. Dr. Rice was made an honorary member of the society in recognition of his long and valuable services. The presentation was made by Dr. John R. Freeman, of Providence, and President Karl T. Compton, of the Massachusetts Institute of Technology, of which Dr. Rice is a graduate, delivered the address.

THE University of Michigan has been presented with the bust of Dr. Cyrenus Garritt Darling, professor emeritus of oral surgery, who for thirty-seven years was connected with the School of Medicine and Surgery and the College of Dental Surgery. The ceremony was held at his home, the presentation being made by Dr. Frederick Novy, professor of bacteriology, who spoke for the donors. The bust was accepted for the university by President Alexander Grant Ruthven, who spoke of the services that Dr. Darling had rendered to his school, to his state and to humanity. The bust is the work of Mr. Carleton W. Angell, artist in the university museums and instructor in modeling in the College of Architecture.

DR. BYRON H. JACKSON, of Moses Taylor Hospital, Scranton, Pennsylvania, was elected president for 1932 at the recent congress at St. Louis of the Radiological Society of North America. He succeeds Dr. Francis Carter Wood, of Columbia University.

AT a recent meeting of the New York Academy of Medicine, Dr. John A. Hartwell, president of the academy, was re-elected for a second term of two years. Dr. Lewis A. Connor, second vice-president, will automatically become first vice-president at the beginning of the new year. Dr. Frederick Tilney, professor of neurology in the College of Physicians and Surgeons of Columbia University, was elected second vice-president to fill the term of Dr. John O. Polak, who died last summer. Dr. Harlow Brooks was elected third vice-president to succeed Dr. Edwin Beer.

PROFESSOR A. C. DIXON has been elected president of the London Mathematical Society. The vice-presidents are Professor S. Chapman, Professor H. Levy and Mr. T. L. Wren.

Nature reports that the following officers have been elected for the Cambridge Philosophical Society: *President,* Professor A. Hutchinson; *Vice-presidents,* Mr. G. Udny Yule, Dr. W. H. Mills, Mr. F. T. Brookes; *Treasurer,* Mr. F. A. Potts; *Secretaries,* Mr. F. P. White, Dr. J. D. Cockcroft, Dr. H. Hamshaw Thomas; *New Members of the Council,* Dr. R. H. Rastall, Mr. C. F. A. Pantin, Mr. N. F. Mott.

DR. ESMOND R. LONG, professor of pathology at

the Graduate School of Medicine of the Division of Biological Sciences of the University of Chicago, has resigned to become director of laboratories of the Phipps Institute of the University of Pennsylvania, his resignation to become effective in July, 1932.

DR. EWEN M. MACEWEN, professor of anatomy at the University of Iowa College of Medicine, has been appointed head of the department to succeed the late Dr. Henry J. Prentiss.

THE *Experiment Station Record* reports that Dr. Frank T. Shutt has retired as Dominion chemist and assistant director of experimental farms of the Canadian Department of Agriculture, thereby terminating a public service of forty-four years. Mr. L. E. Kirk, professor of field husbandry at the University of Saskatchewan since 1922, has been appointed Dominion agrostologist at the Central Experimental Farm, Ottawa. Dr. Allen Deacon has been appointed Dominion animal geneticist.

THE Macbeth-Evans Glass Company, Charleroi, Pennsylvania, has established in the Mellon Institute at Pittsburgh a fellowship in illuminating glassware to which Dr. Rob Roy McGregor, of the Mellon Institute research staff, a specialist in physical chemistry, has been appointed.

M. EMILE PICARD, permanent secretary of the Paris Academy of Sciences, has been elected a member of the French Council of Public Instruction.

DR. ALFRED STENGEL, vice-president of the University of Pennsylvania, in charge of the medical group, has been elected a member of the board of managers of the Wistar Institute to fill the vacancy caused by the death of Mr. Arthur L. Church.

DR. WILLIAM D. CUTTER has been appointed secretary of the Council on Medical Education and Hospitals of the American Medical Association.

DR. ORLANDO H. PETTY has been appointed health officer of Philadelphia following the death of Dr. Andrew A. Cairns in September.

DR. W. F. FOSHAG, curator of mineralogy in the U. S. National Museum, has returned from field-work in Mexico, where he visited mines and studied the mineral deposits in the states of Zacatecas and San Luis Potosi.

DR. F. VENING MEINESZ, of the Dutch Geodetic Commission, an expert on the measurement of gravity at sea, is coming to the United States to take part in the International Expedition to the West Indies, sponsored by Princeton University. Dr. Meinesz will attend the meeting of the Geological Society of America at Tulsa where he will give a paper on "Gravimetric Studies in the East Indies and Folded Mountains."

DR. MAJOR GREENWOOD, professor of epidemiology and vital statistics at the London University School of Hygiene and Tropical Medicine, is giving three Herter Foundation lectures at the Johns Hopkins University School of Medicine. Dr. Greenwood was the guest of honor at a dinner of the medical faculty at the Maryland Club on December 3.

ADMIRAL CARY T. GRAYSON, M.D., an alumnus of the Medical College of Virginia, Richmond, delivered its founder's day address on Tuesday, December 1. This marks the ninety-fourth session of the institution. His subject was "The Modern Trend of Medicine."

DR. C. E. K. MEES, director of research and development for the Eastman Kodak Company, delivered the first of the annual series of Aldred Lectures at the Massachusetts Institute of Technology on December 4. The title of Dr. Mees's address was "Reminiscences." At noon on the same day he addressed the Technology Faculty Club.

DR. W. H. TALIAFERRO, professor of parasitology at the University of Chicago, will deliver the third Harvey Society Lecture at the New York Academy of Medicine on December 17. His subject will be "Infection and Resistance to the Blood Inhabiting Protozoa."

DR. G. CANBY ROBINSON, director of the New York Hospital-Cornell Medical College Association of New York City, delivered the History of Medicine Lecture at Vanderbilt University on December 3. His subject was "The Liberators in Medicine—Vesalius, Paré and Paracelsus."

THE HONORABLE BERTRAND RUSSELL was the speaker before a general convocation at the University of Oklahoma, Norman, on November 23. His subject was "The Scientific Outlook." He also spoke to the members of the staffs of the departments of philosophy and of the several natural sciences at a luncheon given under the auspices of the department of philosophy.

DR. OLIVER KAMM, director of research of Parke, Davis and Company, Detroit, was the principal speaker before the New York section of the American Chemical Society on the evening of December 4. He spoke on "Chemical Investigations in the Field of Ductless Glands."

AT the inaugural meeting on November 7 of the eighty-third session of the Royal Canadian Institute, Dr. E. F. Burton, professor of physics at the University of Toronto, delivered the presidential address, entitled "Seeing the Invisible." The lecture was in celebration of the Faraday-Maxwell Centenary.

THE biennial Huxley Lecture on recent advances in

science in their relation to practical medicine was given at Charing Cross Hospital Medical School on November 26, by Sir Almroth Wright. His subject was "Immunity: the Old Doctrine and the New."

AT a recent meeting of the Royal College of Surgeons, London, the appointments were announced of Dr. Robert Cruickshank, of the University of Glasgow, as Milroy Lecturer for 1933, and of Professor Edward Mellanby as Croonian Lecturer, 1933.

THE Oriental Institute on the campus of the University of Chicago, built at a cost of $1,500,000, which is the largest archeological headquarters in the world, was formally opened and dedicated on December 4. Dr. James H. Breasted, as director of the institute, unlocked the gates of the five exhibition halls —those for the Egyptian, the Assyrian, the Assyro-Babylonian, the Persian-Moslem and the Hittite-Palestinian civilizations. The speakers, in addition to Dr. Breasted, were Dr. Raymond Fosdick, of the Rockefeller Foundation, and Dr. John H. Finley, associate editor of *The New York Times.*

GROUND was broken on November 9 for the Division of Plant Pathology at the Princeton branch of the Rockefeller Institute for Medical Research. The new buildings will consist of a laboratory, 144 feet by 40 feet, two and one-half stories in height, eight greenhouse units, each 65 feet in length, and a potting shed. Dr. Louis O. Kunkel, of the Boyce Thompson Institute for Plant Research, will be in charge of the new division. The buildings were designed by Messrs. Coolidge, Shepley, Bulfinch and Abbott, of Boston, and are being constructed by Matthews Construction Company, of Princeton, New Jersey. The name of the Princeton branch has been changed to the Department of Animal and Plant Pathology of the Rockefeller Institute for Medical Research.

THE house which John James Audubon built and in which his last years were spent is to be saved after having been abandoned to the wreckers, according to an announcement made by Harold W. Decker, an ornithologist of the Bronx. The building, which stands now below the viaduct at Riverside Drive and 155th Street, New York City, hemmed in by tall apartment houses, is being removed in sections, to the new park site provided by the city at Riverside Drive and 161st Street. There it will be restored to the condition it was in when Audubon entertained his friends, in his home away from "the crazy city," far to the south. The removal expenses have been underwritten anonymously and a fund of about $25,000 will be needed to complete the work of restoration. The National Association of Audubon Societies, 1974 Broadway, New York, N. Y., will receive contributions.

ACCORDING to the *British Medical Journal* Lord Moynihan, president of the Royal College of Surgeons of England, laid the corner-stone of the Wellcome Research Institution on November 25. This is the new building now in course of erection in Euston Road and Gordon Street, W.C., London. When completed the institution will embrace the following affiliated laboratories and museums: bureau of scientific research, physiological research laboratories, chemical research laboratories, historical medical museum and museum of medical science. The architect's design for the building was exhibited at the Royal Academy last summer.

DIRECTOR BARTON WARREN EVERMANN, of the California Academy of Sciences, announces that on December 3 the power cruiser *Valero III,* owned by G. Allan Hancock, left San Pedro, California, under the auspices of the academy, bound for Central and South American waters. The primary object of the expedition is the study and collection of marine life, especially fishes, from those tropical seas. Provision has been made for the use of dredges, trawls, traps and other forms of collecting equipment, some of which is newly designed for special purposes. The program calls for stops at Mazatlan, Acapulco, Panama, Cocos Island, Malpelo Island and the Galapagos. At the last place special attention will be given to stocking the eight tanks being carried, with live fishes for display in the Steinhart Aquarium of the California Academy of Sciences in San Francisco. Mr. Alvin Seale, superintendent of the aquarium, is in immediate charge of the scientific work, assisted by Dr. L. G. Hertlein, who will make general collections, particularly of mollusca and fossils. Collections of living reptiles, birds and marine mammals will be obtained for the San Diego Zoological Park, this phase of the work being under the special charge of Mr. Charles B. Perkins, of Denver, Colorado.

THE *Journal* of the American Medical Association writes under "Current Comment" as follows: "Repudiation of the Bilbo administration, which so nearly wrecked the educational institutions of Mississippi, occurred recently when Martin Sennett Conner was overwhelmingly elected governor. The standing of the medical school of the university was threatened in 1930 when the dean and the entire faculty were ousted and others put in their places. A partial restitution took place when the Council on Medical Education and Hospitals of the American Medical Association, the Association of American Medical Colleges, and other organizations interested in higher education, the united medical profession of Mississippi and an aroused public opinion protested against such high-handed and destructive tactics. Most of the faculty members were recalled and Dr. P. L. Mull, professor of anatomy, was named acting dean. Professors were

graciously lent to the school by Vanderbilt University and the University of Tennessee. The medical school was nursed along through this trying period, but it is now evident that the people of the state of Mississippi were eagerly awaiting the time when they could administer a death blow to further officious interference with their schools. The new governor will no doubt be constructive rather than destructive in educational matters."

THE London *Times* reports that an extension to the research laboratories of the English Steel Corporation, Limited, at Vickers works, Sheffield, was opened on November 8 by Sir Joseph Thomson, master of Trinity College, Cambridge. He described these new laboratories "as a signal token of the advance in importance attached to research by industry. It was a comparatively recent thing for research and industry to be linked together. Not long ago the bulk of the people in industry took the view that things might be 'all right,' but would not work in practice, and in those days science and industry were rivals, well aware of each other's imperfections. He did not suggest that all the fault was on the side of the manufacturers, for often men of science did not realize the immense amount of work which had to be done to take a discovery from the shelter of the laboratory into the rough-and-tumble of the works. The transition often required years of work and cost much. Between the laboratory and the works was a long stretch of country through which it was difficult to find a way, but when the way had been found the reward was very rich. To the people engaged in the laboratories he particularly emphasized the importance of looking for the unexpected, for it was from the unexpected discovery that new industries were formed and new employment created."

THE department of zoology and physiology of Wellesley College, housed in temporary quarters since 1914, when College Hall was destroyed by fire, now occupies a new building. The erection of the zoology unit completes Sage Hall, the botany wing of which was opened in 1927. The building, modern in construction and equipment, includes laboratories for the introductory course and for more advanced courses in zoology and physiology; lecture rooms; small private laboratories for the staff; department offices; adequate storage space. Among the features of special interest which contribute to the convenience and teaching value of the new building the following may be mentioned: room for giving new courses long postponed; a departmental library, a memorial to Miss Caroline B. Thompson, a former member of the department; a demonstration room for the exhibition of illustrative material for the elementary course; a museum for the display of collections long kept in storage; a small greenhouse; a vivarium including mammal rooms with out-of-door runs, turtle pools, and frog tanks, fresh and salt water aquaria, Daphnia tanks. Mr. Kitson, of the State Fish Commission, has given to the department between three and four hundred fresh water fishes including pickerel, sun fish, speckled trout and pout. As soon as the salt water has been installed Mr. O'Brien, of the South Boston Aquarium, has promised the department salt water forms. A tame skunk, the gift of Benson's Animal Farm, Hudson, N. H., occupies one of the mammal rooms; a well-arranged monkey room still awaits an occupant. The vivarium not only serves as quarters for guinea pigs and rats used in dietary experiments, etc., but it will, it is hoped, stimulate in students and staff an interest in the natural history side of biology.

IT is planned to erect for the Forest Products Laboratory of the University of Wisconsin, at a cost of $900,000, a building to provide facilities for every known technical test of wood in all stages of its transformation from logs to paper and turpentine. The building, which will be U-shaped, about 275 feet long and for which ground already has been broken, will be six stories high, with 175,000 square feet of floor space. It will stand on a ten-acre site overlooking Lake Mendota at Madison. It is hoped that the building will be completed in August, 1932. Six floors at one end of the building will be used as pulp and paper research laboratories. Provision is made for a large timber preservation laboratory, a wood fermentation unit, fractionating stills, a general section of wood chemistry, wood glueing, painting, finishing and fireproofing laboratories, and facilities for the study of wood fungi and insect pests. A railroad siding, a power plant of 630 boiler horsepower, and a number of service elevators, hoists and monorails will be required. The laboratory was established in 1910 and has occupied buildings owned by the University of Wisconsin. The work has been carried on for several years by a staff of two hundred members and the laboratory has outgrown its present quarters. The state appropriation has recently been doubled. The land on which the new building will stand was given by the regents of the University of Wisconsin.

ACCORDING to the *Experiment Station Record* the Minnesota State Legislature has made provision for increased facilities for both field crop and horticultural plant breeding investigations in the Agricultural Experiment Station of the University of Minnesota. An appropriation of $30,000 was made for the erection and equipment of a farm crops field house at University Farm. This will be used for the curing and storing of nursery and increase stocks and will

contain weighing, drying and preparation rooms and facilities for cleaning and storing seed stocks of various kinds. For the fruit farm near Zumbra Heights in the Lake Minnetonka district, $9,000 was appropriated for the purchase of additional land and $13,500 for an office building and laboratory. Nearly all the investigations in fruit crop breeding are conducted at this farm, and the laboratory will provide much-needed facilities and greatly expedite the making of records and the interpretation of results.

DISCUSSION

CYCLONE AND ANTI-CYCLONE

IN some recent letters, published[1] and personal, Sir Napier Shaw suggests that we might with profit employ the terms *"air-sink"* and *"air dump"* for cyclone and anticyclone. Both of the last-named have done honorable service, and it will be long before they are eradicated from conventional usage in all treatises on airgraphics. But even as we are eliminating the almost unpronounceable word meteorology, so we may gradually dispense with terms that have outlived their usefulness. Cyclone came to us from Piddington, with the Greek κυκλος or coil of a snake, and anti-cyclone from Francis Galton, as the opposite of an uprising, rotary wind structure. It would now seem that we have unconsciously overstressed the importance of the circulatory air flow in a depression or cyclone; and so neglected the scooping-out or removal of air on the one hand and the heaping-up or cumulative effect on the other, which is so aptly pictured as a *dump*. This overstressing of the "low" as shown by the surface air flow and a positive insistence upon the fundamental physical relation that air flow is initiated by pressure, and pressure only, has resulted in missing a most important factor in the formation of areas of high and low pressure.

To quote Sir Napier Shaw:

> So pressure-gradient comes to be the mere index of the response of an air current to the centrifugal force of the earth's rotation aided or counteracted by any local curvature of the air's path.

Here then we come to a new point of view, as explaining the origin, also maintenance, of highs and lows, and this is of importance in forecasting the weather, and an understanding of the daily maps. Cyclone and anticyclone are really created and maintained by the winds of the straight isobars that lie between them. To quote further from Sir Napier

> The high and the low are mere incidents of the relative motion of the air currents of different directions. In the northern hemisphere wherever the passing currents keep the English rule of the road, with opposing traffic on the right, high pressure (and generally fine weather) between them is the inevitable consequence; but wherever the atmosphere adopts the continental rule of keeping the opposing traffic on the left, there a "low" between them is equally inevitable.

This fundamental law in forecasting we have recognized for some years at Blue Hill Observatory, and may be expressed briefly as, "An air flow from northwest, north or northeast, in advance of a flow of warm, moist air from south or southwest, is less likely to give precipitation and form a depression than when the southerly air flow is in advance of a dry, cold flow from the north." In keeping with the new point of view, we should perhaps mark storm paths, not from the loci of minimum pressure but from the points of wind conflict.

Much more could be said concerning an automatic balance between wind velocity and gradient under the influence of the earth's rotation; but it must suffice for the present to call attention to this shifting of attention from pressure minima to air-flow effects as the really important dynamical agents.

Sir Napier has also calculated the energy of the horizontal motion of a 100 meter layer of air, in thickness, with pressure interval of 2 kilobars as approximately 26,000 kilowatt-hours, varying with height and latitude.

ALEXANDER MCADIE

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[1] *Nature*, June 27, 1931, "Potential Temperature and the Stratosphere"; August 8, 1931, "The Energy of Horizontal Atmospheric Motion."

THE UNCERTAINTY PRINCIPLE

IN his note on "The Uncertainty Principle and Free Will" published in SCIENCE for August 14 (p. 172), Professor A. H. Compton seems to overlook the important distinction between a thing which is *indeterminable* and one which is *indeterminate*. No one can predict with accuracy and certainty what the weather will be to-morrow, to say nothing of predicting what it will be a week or a month hence. But I think no scientific man would claim that because the weather is indeterminable it is indeterminate—that the weather to-morrow will not depend, inevitably, on conditions which exist to-day.

It may be an "even chance" whether the photon of which Professor Compton writes will enter one or the other of two photoelectric cells, but it is illogical to suppose, for that reason, that the conduct of the photon is not determined by complex conditions of such a character that prediction is impossible. The fact that so minute an event may produce tremendous

results has no connection with the question whether the event is determinate or not.

Darwin may be right when he says that the problem of "free will" "is a philosophic one outside the thought of physics," but such a statement depends on one's definition of physics and of science. It is true if we include in science only those things which are fully known and can be mathematically demonstrated. In an article by Professor Evan Thomas on p. 173 of the same number of SCIENCE several beautiful illustrations are given of important advances in science which began, not with rigid mathematical reasoning or logical conclusions from a set of observations, but by a quite different process. Such advances must always be submitted, afterwards, to the test of agreement with observation, and, if possible, to mathematical treatment. Science would be a very poor affair if it rigidly excluded all ideas for which this process is incomplete—indeed, is it possible to say of any fundamental idea that the process is complete? Science and philosophy, in their higher reaches, should be identical.

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THE UNCERTAINTY PRINCIPLE AND FREE WILL

A RECENT number of SCIENCE[1] contains an extremely interesting article by Professor A. H. Compton, showing the possible effect of Heisenberg's uncertainty principle upon macroscopic phenomena. It illustrates beautifully a point which has been frequently overlooked, namely that, in certain instances, uncertainty is cumulative and creeps into large scale events.

There has been considerable speculation as to the possible significance of this fact relative to the problem of free will. The present note endeavors to clarify the relation between these two issues and to show, incidentally, that no connection between them exists.

We desire mainly to point out two things:

(1) In Compton's example, uncertainty governs the fate of the photon. The response of the amplifying device appears dependent upon the photon's fate. The amplifying action is causal in the direct, acausal in the indirect sense. "Freedom of choice" in the amplifying device would involve its capability of guiding or affecting the photon's fate, a postulational element which is metaphysical and proves to be unreasonable upon closer inspection.

Any attempt to establish the possibility of free will on the basis of physical uncertainty has also a formal flaw from the point of view of the all-embraciveness of quantum theory. The uncertainty principle has transformed the causally closed into a causally open world. Hence a proposal to reverse this transformation would appear inconsistent with recent developments in theoretical physics. It is to be noted that the establishment of free will is such an attempt of filling the causal gap by supplying the lacking determinant in form of the individual's decision, and is therefore contrary, in one sense at least, to the spirit of quantum dynamics. It must be admitted, however, that this last consideration is stringent only for those who refuse to supplement the physical world by extraphysical elements.

(2) The second and major point of this note regards the problem of freedom of will itself. This philosophical problem arose in connection with that of individual moral responsibility and has to do with the determining factors of human motivation. It belongs to a domain which is intrinsically foreign to physical lawfulness and must be distinguished clearly from the somewhat less problematical question of freedom of action. Philosophers have usually observed the demarcation (*actus elicitus voluntatis vs. actus imperatus voluntatis*). Compton's argument demonstrates a possibility for freedom of action—though a very limited one—this action being the release of one of a number of physically indeterminate sequences of events, which occurs after the volition has been formed. But it does not touch the problem of the motivation of this volition. Hence there is no intelligible connection between quantum-mechanical uncertainty and free will.

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[1] "The Uncertainty Principle and Free Will," SCIENCE, 74: 172, August 14, 1931.

THE CLASSIFICATION OF PYTHIUM[1]

SPARROW has presented in SCIENCE 73: 41–42, a point of view on the classification of members of the genera Nematosporangium and Pythium which, although correct in certain respects, is misleading in certain others. He has argued that the genus Nematosporangium be dropped and its members included in Pythium, that certain of the organisms now placed in Pythium be transferred to Sphaerosporangium and that the members of the genus Pythium with lobulate prosporangia be placed in the genus Rheosporangium.

Sparrow is correct in his first assertion in dropping Nematosporangium and placing its organisms in Pythium, as far as priority is concerned. It is true that the original type species of Pythium was *P. monospermum* Pring,[2] which is now included in Nematosporangium. This species, however, is very rare and the genus Pythium became more known and

[1] Published with the approval of the Director as Miscellaneous Paper No. 11 of the Experiment Station of the Association of Hawaiian Pineapple Canners, University of Hawaii.

[2] *Jahr. Wiss. Bot.*, I, p. 288, 1858.

typified by the later discovered *P. proliferum* de Bary[3] and *P. debaryanum* Hess,[4] because of their wider distribution and greater economic importance. Both *P. proliferum* and *P. debaryanum* differ from *P. monospermum* to such an extent as to justify the creation of two genera. Fischer[5] created at a later date the subgenera Nematosporangium and Sphaerosporangium and placed *P. monospermum* in the former subgenus and *P. debaryanum* and *P. proliferum* in the latter. Schröter[6] in 1897 elevated Nematosporangium to generic rank and placed all the organisms then in the subgenus Sphaerosporangium in Pythium. This scheme of classification has been approved by Lindau[7] and recommended by Fitzpatrick[8] and, in the opinion of the writer, it is practical and divorced from complications and ambiguity.

Pythium debaryanum came to be known as the type species of the genus in the pathological literature, because of its constant association with seedling root rot. Very few plant pathologists and even mycologists have ever seen *P. monospermum* but nearly all have had some practical experience with *P. debaryanum*. It is through such an experience that the morphology of practically all pythiaceous organisms has been compared with that of *P. debaryanum*. One will readily see the fallacy and injustice of placing members of the genus Nematosporangium under Pythium especially in the case of *Rheosporangium aphanidermatum* Edson.[9] *R. aphanidermatum* does not vary any more from *Pythium monospermum* than does *P. proliferum* from *P. debaryanum*. It is, therefore, as true a member of the genus Pythium as the type species *P. monospermum*. Yet, in spite of all this evidence, Edson created the new genus Rheosporangium to find a place for his organism! The writer believes that the fault is not with the investigator, but with the taxonomic system because it has failed to differentiate properly between completely distinct organisms.

Sparrow recommends the reestablishment of the genus Rheosporangium to include all those members of Pythium with lobulate prosporangia. It is very unfortunate that Sparrow did not read very carefully the description of *P. monospermum*, or else he would have noticed that the hyphae of this organism possess bud-like outgrowths which came to be known by later investigators as prosporangia. The German text in connection with the lobulate prosporangia of *P. monospermum* reads as follows: ". . . Fäden oft mit vielen Kurzen annähernd rechtwinkelig ansetzenden Seitenästen. . . ."

My answer to Sparrow's criticism of my paper[10] for the non-segregation of members of Nematosporangium with filamentous prosporangia from those with lobulate ones is that I have never seen any species of Nematosporangium (*Pythium monospermum* type of organisms) lacking the lobulate prosporangia (bud-like outgrowths of Butler or plasmatoögoses of the writer.[11] These bodies vary in size and number in different species, but they are present, nevertheless, in all species. With species which reproduce sexually very readily and abundantly the lobulate prosporangia are not very numerous, and *vice versa*.

If the recommendations as proposed by Sparrow are accepted there is a danger of leaving the genus Pythium without any members. If all of the species with lobulate prosporangia including *P. monospermum* are placed in Rheosporangium and those with spherical prosporangia including *P. debaryanum* in Sphaerosporangium, then there will not be left any more members for Pythium.

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[3] *Jahr. Wiss. Bot.*, II, p. 182, 1860.
[4] *Dissert.* Halle, 1874.
[5] Rabenhorst's "Kryptogamen Flora von Deutschland, Oesterreich und der Schweiz." IV. *Abt. Leipzig.* 1892.
[6] *Engler-Pranlt.* "Natürliche pflanzenfamilien. Pythiaceae, 104–105, 1897.
[7] "Die mikroskopischen pilze," Berlin, 1922.
[8] *Mycologia*, 15: 166–173, 1923.
[9] *Jour. Agr. Res.*, IV: 279–291, 1915.

"TASTE DEFICIENCY" FOR CREATINE

THE observation that to certain individuals *p*-ethoxy phenyl thiourea tastes bitter, while to others it is tasteless has led to Professor L. H. Snyder's study of the inheritance of this taste deficiency as reported in SCIENCE for August 7, 1931.

A few years ago the writer, with Mr. P. A. Lasselle,[1] noted a somewhat similar situation with regard to the familiar muscle constituent creatine. We had a sample of what eventually was proved to be this substance submitted to us for identification. The melting point recorded in the literature was somewhat in error, but the properties of the substance suggested that it might be creatine.

Creatine, however, was described in the literature as bitter, whereas the substance in question seemed to both of us to be as tasteless as chalk. Further study convinced us, nevertheless, that it was actually creatine. It was not, I believe, until we had submitted it to the fifth person that we found one who reported a bitter taste.

The fact that even this familiar food constituent has these distinctive reactions on different individuals is perhaps a significant one. Since a pound of lean meat may contain nearly two grams of creatine it

[10] SCIENCE, 71: 323–324, 1930.
[11] *Mycologia*, 23: No. 4, 1931.
[1] *Jour. Am. Chem. Soc.*, 48, 536, 1926.

would be surprising if this taste difference did not manifest itself in giving meats distinctive flavors for different individuals. Especially should this be so for soups made from lean meat which must contain a considerable quantity of extracted creatine. Possibly the taste which creatine has for certain individuals is destroyed by the presence of other food constituents.

The problem is associated with the more general one of individual metabolic idiosyncrasies, which calls for extensive study. It is a fact which is not always recognized in medical practice that occasional individuals react in quite a distinctive way toward particular drugs, among which are such familiar ones as morphine and novocaine. A man of my acquaintance who has a normal sense of smell in other respects is unable to detect the odor of skunk. Even a sample of n-butyl mercaptan, which is the perfume carried by these animals, had no unpleasant odor for him.

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SCIENTIFIC BOOKS

The History and Work of Harvard Observatory, 1839–1927. By SOLON I. BAILEY. New York and London, McGraw-Hill Book Company, Inc., 1931. (Harvard Observatory Monographs, no. 4.)

SELDOM, if ever, has a subject concerned with the history of science received as interesting a treatment as in the book under review. The volume "The History and Work of the Harvard Observatory, 1839–1927" is the fourth of the well-known monographic series issued by this observatory. It is from the pen of the late Dr. Solon I. Bailey, who was Phillips professor of astronomy, emeritus, at Harvard University, and one of the oldest and most distinguished members of the Harvard Observatory staff. Dr. Bailey's long connection with the practical research of the observatory made him intimately acquainted with every phase of the important work carried on there, and he was therefore well prepared to write a unique historical account as set forth in this book. It is indeed fortunate when one who reaches the honored title emeritus can give his time to introspection and reflection upon the accomplishments of his period and of his institution. Harvard College Observatory ranks as the oldest research observatory in the United States, and it is therefore peculiarly fitting that a historical review should be placed before scholars. This observatory may be said to have found its roots deep in our early Colonial period—for astronomy seems to have been taught and "practiced" almost from the date of the founding of this Puritan college in 1636.

The summary of the vast contributions of the observatory is written in Dr. Bailey's simple and characteristic narrative form, which is not lacking in vividness and humor and is so presented as to be of service to both the layman and the professional scholar. The book is composed of three large divisions, in logical sequence, with a total of twenty-one chapters. The first part gives briefly the historical outline of the ancestry of the observatory, showing how the pioneer efforts in organizing research in astronomy were developed, and an account of the first astronomical expedition in this country by Harvard College to observe the transit of Venus in 1761. There is also given a short life sketch of the first Colonial astronomer, John Winthrop (1714–1779). Unfortunately this chapter contains several minor errors in historical facts and dates. Thomas and William Brattle were brothers and not father and son. Both were prominent scholars, Thomas Brattle furnishing observations on the Comet of 1681 which were highly important to Halley and Newton in developing the first calculations of the orbit of a comet. William Brattle was the first tutor in philosophy at Harvard College. Dr. Bailey calls attention to the great influence exerted upon science by John Quincy Adams, the sixth President of the United States, who was the godfather of three observatories in the United States, which were called by his critics the "lighthouses of the sky." The chapter continues with a description of the temporary quarters of the observatory, known as the Dana House, which housed the few instruments in possession of the first director, William Cranch Bond. The present observatory owes its origin to the public interest shown at the appearance of the Comet of 1843. A complete account is given of the gradual enlargement of the instrument equipment and the notable number of expeditions to observe solar eclipses and to determine the location of new sites for auxiliary observatories. The final chapter of this historical part treats of the various publications of the observatory which afford to students of practical and theoretical astronomy unlimited resources for further researches.

Part two, which is devoted to scientific problems, is practically a complete study of the contents of the publications known as the Annals, Bulletins, Monographs, Reports and Circulars. It also reveals the pioneer character of many of the problems undertaken by this observatory, of which, of course, the most interesting is the account of the adoption of photography in the study of celestial phenomena. The difficulty with the so-called "collodian wet-plates" and

the daguerrotype process was finally overcome by the dry, high-speed plates, and to-day the main reliance for advances in practical research is on photographic processes. No observatory to-day contains such a wealth of valuable photographic plates as the Harvard Observatory collection. The invention of this photographic process made possible the first systematic study of stellar spectra, photometry and charts of the standard regions of the sky. The Henry Draper Catalogue of the classification of the spectra is one of the great contributions of this observatory. The later period of the research work of the observatory is centered upon the problem of cosmogony, the study of variable stars, novae, clusters, nebulae and the Magellanic clouds. A survey of the wealth of analytic material here set forth is beyond the limits of this review; suffice it to say, no reader can afford to overlook part two if he wishes to understand the fundamental problems in astronomy and the methods of approach. Dr. Bailey's ability to synthesize the whole of Harvard's contributions to astronomy is abundantly demonstrated here.

The third division of this book is devoted to biographical sketches of the principal members of the staff, beginning with the Bonds (father and son) and ending with the benefactors of the observatory. Dr. Bailey has written of the lives of the first four directors with sympathetic feeling and appreciative understanding of their struggles and labors, and pays tribute to their sturdy New England characters and philosophy coupled with perseverance, purposiveness and idealism. It is interesting to note in passing that William C. Bond installed the first large refractor (15 inch) in this country, and he also made the first electric chronograph. Bond was the first American associate of the Royal Astronomical Society of London. George P. Bond, the second director, was better trained for his duties than his father, having graduated from Harvard College. He was also the first to make systematic observations and critical studies of nebulae. His studies of the Orion nebulae and Donati's comet will probably remain as classics for many years, and as he was mathematically inclined, he carried his researches much further than his father. He was a pioneer in celestial photography, and the sum total of his astronomical contributions brought him the first Gold Medal awarded to an American by the Royal Astronomical Society of London, 1865. Joseph Winlock was the third director, and, like his predecessor, his term was of short duration. His directorship was known as the period of transition, as it carried the observatory out of its pioneer days and over to the modern period which began with E. C. Pickering in 1877. No comment is necessary upon the work of Pickering, as it is well known to contemporary astronomers. The statement that Pickering was the first president of the American Astronomical Society is incorrect and should be corrected in subsequent editions. This honor fell to Simon Newcomb, who presided from the first to the seventh meeting of this society, 1899 to 1905. Pickering was elected in December, 1905, immediately after the New York meeting. This error may have occurred in noting the contents of the title page of Volume 1 of the Publications of the American Astronomical and Astrophysical Society, which is misleading. The number of leading American astronomers, as well as foreign associates, who participated in the work at the observatory, either as graduate students or independently, is notably large. Among the American names that stand out are Asaph Hall, C. W. Tuttle, Truman Stafford, Arthur Searle, S. P. Langley, C. S. Peirce, W. A. Rogers, W. Upton, O. C. Wendell, Seth Chandler, A. L. Rotch, Joel Metcalf and Edward S. King.

Under Pickering's administration it is interesting to note that a large number of women were employed in actual research, and some have made considerable advances in their particular fields, among them being Mrs. W. A. Fleming, Dr. Annie Cannon, Miss H. S. Leavitt, Miss Antonia C. Maury and perhaps a dozen others. Pickering had also a remarkable faculty for interesting younger men and women in research work, and this interest has expressed itself in the formation of a society composed of amateurs for the study of variable stars, known as the American Association of Variable Star Observers.

Following the death of Pickering in 1919, Dr. Bailey served as acting director until 1921, when Dr. Harlow Shapley was elected to guide the future of Harvard Observatory. Shapley's work is too extensive and well known to compress within the limits of this review.

The book contains a double index, one for names and another for subjects, which, together with an extensive list of footnotes, makes it a book easy of reference. The illustrations for the most part are good, the type pleasing, and the paper is such that the book will stand use for years to come.

In this book Dr. Bailey has left a wonderful tribute to the observatory he served so long, and makes too inconspicuous the part he took in the study of practical and theoretical astronomy. The compactness of the study of the accomplishments of the observatory is highly commendable, and great credit is due the author for placing such a volume in the hands of historians. It is particularly recommended to all directors of observatories contemplating a similar volume for their own anniversaries.

FREDERICK E. BRASCH

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A METHOD FOR THE STUDY OF CHROMOSOMES IN ENTIRE INSECT EGGS

IN view of the numerous difficulties attending the study of chromosomes in insect eggs it is believed that the method outlined below may prove of value to other workers in the field, as it has to us. Its essential feature is the use of the recently developed Feulgen test for thymonucleic acid[1] by means of which chromatin alone may be stained, leaving the other components of the cell almost transparent. Applying this method to the entire egg it is possible, in suitable material, to reveal the chromosomes distinctly without staining the yolk or other egg constituents, with the result that the maturation and cleavage divisions may be studied with ease.

Not only does this method eliminate the laborious processes of embedding, sectioning and examining deeply stained serial sections, but it adds greatly to the reliability of the observations and also greatly extends the usefulness of each good preparation. Reliability is enhanced by the fact that in the entire egg, thus prepared, no mechanical disturbance of parts has occurred and the inter-relations of the components (polar bodies, egg nucleus, sperm, etc.) are obvious. It is not necessary to reconstruct as with sections. Usefulness of the individual preparation is increased by the fact that all the mitotic figures are intact; and both usefulness and reliability are increased by the fact that the egg may be moved about (rotated) in such a way as to permit bringing each figure into the most favorable position for study, and to permit examination of individual figures in different aspects (side view, polar view, etc.).

We have used the method only on the eggs of one species—the fungus gnat *Sciara coprophila* Lint. The eggs of this fly are approximately 0.2 mm in length and 0.1 mm in thickness.

In such eggs it is possible to examine the chromosomes in any part of the egg with a 2 mm oil immersion objective and in most cases with a 1.5 mm objective. From our experience it seems probable that the method could be used satisfactorily even with considerably larger eggs for a study of the maturation divisions and of such cleavage divisions as occurred near the periphery of the egg, because of the possibility of rolling the egg about until the desired part becomes uppermost. In the case of eggs with opaque or too resistant outer membranes such membranes would, of course, have to be removed mechanically, or punctured, as the case required.

[1] Lee, "Microtomist's Vade-mecum," 9th edition, pp. 437–438 and footnote, p. 438.

The procedure we have followed is given below: At suitable intervals after the eggs are laid they are fixed in a modification of Carnoy's solution (equal parts chloroform, absolute alcohol and glacial acetic acid) for from one half hour to two hours, and washed in several changes of absolute alcohol over a period of at least two hours. Then they are passed through the higher alcohols, 95 per cent., 85 per cent., 70 per cent. (one hour each), the lower alcohols, 50 per cent., 30 per cent., 15 per cent. (one half hour each) and tap water (several changes) in preparation for the Feulgen treatment. For our material the stain is most successfully obtained in the following manner:

(1) Place eggs for 15 minutes in cold normal HCl solution, (2) transfer for 8–10 minutes to a similar HCl solution heated to 60° C, (3) rinse in cold HCl solution, (4) place for 2–5 minutes in SO_2 water, (5) stain 1 hour in fuchsin sulfuric acid solution, (6) wash in two changes (fifteen minutes each) of the SO_2 water, (7) rinse in several changes of tap water. The HCl and SO_2 solutions must be fresh, and the fuchsin sulfuric acid solution an amber color without red precipitate. The formulae for the solutions and additional precautions as to their use may be found in Lee (*loc. cit.*).

The method requires some experience. Unless properly treated the chromosomes are apt to be pink or pale red, but in suitable preparations they are deep red in color, not unlike the color produced by safranin. The color is relatively permanent.

After staining, the eggs are dehydrated rapidly in alcohol (not more than 5 minutes in each change up to 85 per cent.), cleared in xylol and mounted in balsam in the usual manner on slides or between coverslips. If they are to be moved about and examined in different positions it is best to do the manipulating soon after mounting, although in our experience the balsam may readily be softened around the coverslip with xylol at any time within a few weeks after mounting. A green light filter aids materially in studying the figures.

In rolling the eggs during observation we have used the simple expedient of moving the coverslip to and fro. This usually suffices to turn the eggs. If more accurately controlled manipulation were desired the procedure could be modified as required—*e.g.*, the eggs could be examined in immersion oil without the use of a coverslip. When a coverslip is used it is necessary, of course, to adjust the amount of balsam to the size of the eggs in order to have as little as possible between the egg and the glass and at the same

time to avoid flattening the egg by pressure of the coverslip. In practice this presents little difficulty.

The fixative noted above is used simply because it appears to give the best fixation in our material. Others may be substituted if desired. Contrary to early reports the Feulgen method of staining appears to be applicable to material fixed in any of the ordinary fixatives. We have used it after Fleming, Gilson's mercuric nitric solution and Bouin, as well as Carnoy.

As an aid in transferring the eggs during dehydration, staining, etc., any of the standard methods of handling small objects may be used. We use the method of packing them in Drosophila pupa skins when they are in 70 per cent. alcohol after fixation[2] and then pushing them out of these cases either singly or in groups during the final process of mounting in balsam.

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RECONSTRUCTION WORK BY THE USE OF CELLOPHANE

IN 1930–31 the writer began investigations on the development of the jugular lymph sacs in turtles. In review of the literature on the vascular system, one observes that the only available extra-vitamin methods of studying the development of vascular elements, are by plastic reconstructions and by injections. Excellent as these methods are in studying vascular anatomy, they merely show the extent of the system at any stage and many questions as to the exact way in which growth takes place can not be determined by them. For that reason a new method for studying the development of the system was being sought. It seems hardly necessary to emphasize the advantage of using all possible methods in studying systems, if not always in one's own work, certainly through understanding the value of the observations of others and the necessity of comparing and testing the limitations of different methods.

Material was being sought which was thin and transparent, so depth could be observed when used in reconstructions. Cellophane answered the purpose, it being material of transparency, which is strong, durable and .0017″ in thickness.

Camera lucida drawings were made of serial sections on separate sheets of cellophane. A projection microscope was used for the drawings, so that a relatively large field with a high magnification could be obtained. This material made it possible to check each drawing carefully and quickly with the one preceding, before they were placed in reconstruction form. It was found to be the best method to get every vascular element in the reconstruction and to establish, thereby, a graded series of stages of embryos of different ages, complete in all details, in which the vascular elements could be studied and compared in their proper relations. In some cases it seemed highly desirable to use different colored inks to represent the arteries, veins, lymphatics and nerves.

It seems to the writer that where wax reconstructions are necessary, the use of cellophane marks a decided advancement in the preliminary steps for making the plastic reconstructions. The transparency of the material, making observation of depth possible, gives one an accurate course of the parts under observation in relation to other structures.

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SPECIAL ARTICLES

SIMULTANEITY IN THE ONSET OF POLIOMYELITIS

THE observation has often been made that when multiple cases of poliomyelitis occur in a family or a similar group of children, the onset of symptoms in all the individuals affected is simultaneous or nearly so. Sometimes the first symptoms are weakness or paralysis of muscles; at other times the symptoms are indefinite and mild, with weakness or paralysis of muscles following only after several days, or not at all.

These occurrences point to a common and coincidental exposure to the virus of the group of children affected. From these children, secondary cases of the disease may arise in other children, according to circumstances varying from group to group. The secondary cases will be separated from the primary ones by an interval of one, two or even more weeks, which interval is called the "incubation period."

A corresponding simultaneity is shown in a remarkable manner by groups of monkeys (*Macacus rhesus* and *cynomolgus*) inoculated experimentally with a potent virus by simple nasal instillation. The incubation period in these animals is regular and

[2] C. W. Metz, "A Simple Method of Handling Small Objects in Making Microscopic Preparations." *Anat. Rec.*, Vol. 21, No. 4, pp. 373–374, 1921.

accurate; it falls, in many of the tests, between the tenth and the fifteenth day following the first instillation, or between the seventh and the tenth day after the last instillation.

The striking precision of the phenomenon may have an important bearing on the still discussed question of the mode of infection in epidemic poliomyelitis. No other means of producing the infection in monkeys gives a corresponding, regular result; and no other experimental method of inoculation, through an external portal, gives reliable results at all. The digestive organs in monkeys are impervious to the virus, or the virus penetrating the tract is destroyed quickly. Not only is infection almost never produced by artificial feedings of virus, but monkeys which have resisted repeated artificial feedings are found to be as susceptible as normal or control animals to the nasal instillations.

The regularity and simultaneity with which experimental infection can be induced by dropping the virus of poliomyelitis into the nares of monkeys, afford additional support for the view that the portal of entry of the virus in human beings is the upper respiratory mucous membrane.

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PRIMITIVE OR FILTERABLE FORMS OF BACTERIA

IN a previous note[1] we reported the general occurrence of filterable forms of bacteria in such substances as soils, hay infusions, decomposing manure, human feces and milk. More recently, Sherman, Safford and Brueckner[2] have recorded a quantitative approach to this subject, which indicates that these primitive forms of bacteria are usually present in milk and milk products in greater numbers than are bacteria of familiar type.

The quantitative method in use in this laboratory was based on the assumption, later shown to be correct, that these primitive forms should occur in many substances in greater number than ordinary bacteria which are detected and enumerated by conventional methods. Serial dilutions of the substance under examination are made into glucose-beef infusion broth. These dilution cultures, representing from 10^{-1} to 10^{-13} gram of the original material, are incubated one or two days at 37° C. and then from two to three weeks at 30° C. After incubation, the higher dilutions, which contain no growth of ordinary bacteria, are seeded on the surface of glucose-infusion agar plates. The plates are incubated two days at 37° C. and, if necessary, longer at 30° C., after which they are examined for the delicate growth which Hadley has termed the "G" type colony. Growth has been recorded as positive when on microscopic study, after further culturing if necessary, definite minute cells which would be recognized as "bacteria" were found.

Aside from the quantitative approach, the most significant modification in this technique as compared with those previously used by Hauduroy,[3] Hadley, Delves and Klimek,[4] and others, is the longer incubation of the broth cultures. This prolonged incubation in broth appears to be desirable in order to get definite growth on the first agar plates seeded therefrom.

The numbers of primitive bacteria found by the application of this method are somewhat surprising. Nine samples of soil representing a wide range of productivity have yielded estimates ranging from 10^7 to 10^{12} per gram. Other materials have shown: Fresh human feces, two samples, 10^{12}; sour milk, two samples, 10^{11}; and raw market milk, six samples, 10^8 to 10^{12} per gram.

While the occurrence of these primitive microorganisms in such large numbers may be difficult to believe in the light of previous knowledge of "bacterial counts," they are perhaps not unreasonable. Ordinary bacteria are not infrequently found in numbers approaching and exceeding one billion per gram in certain types of decomposing and fermenting materials. When probable relative sizes are considered, the presence of bacteria in the filterable stage in numbers approximating one trillion per gram appears plausible. In this connection it is of interest to note that Clifton, Schultz and Gebhardt[5] have recently determined the size of the virus of poliomyelitis as probably less than "50 μμ in diameter."

With reference to the microscopically definite cells which are found in "G" type cultures, it should be remembered that workers in this field appear to be unanimous in the belief that these organisms represent a partially transformed state between the filterable (perhaps ultramicroscopic) and the non-filterable stages of the bacteria. Hadley, Delves and Klimek[4] have furnished rather definite evidence that this is in fact the case.

One of the most interesting points about the primitive forms of bacteria is their inertness on ordinary bacteriological media. When these forms are cultivated in the laboratory until they appear microscopically as true bacteria, they still make only very meager growth on agar and do not cause the familiar

[1] SCIENCE, 73, 448, 1931.
[2] *Proc. Inter. Dairy Congress*, Copenhagen, July, 1931.
[3] "Les ultravirus et les formes filtrantes des microbes," Paris, 1929.
[4] *Jour. Infect. Diseases*, 48, 1, 1931.
[5] *Jour. Bact.*, 22, 7, 1931.

changes in culture media which are characteristic of bacteria of ordinary type. In other words, it appears that morphological reversion runs very much ahead of physiological transformation. This has been noted by other workers. It apparently was the case in the excellent work of Smith and Jordan[6] on the diphtheria organism. Dr. Hadley informs us (personal correspondence) that it has been true in all the work which he has done on this subject. Kendall,[7] in his recent important contribution to this field of study, reports the same observation. In their exceptionally complete work on the Shiga bacillus, Hadley, Delves and Klimek[4] succeeded in accomplishing a total physiological transformation of the organism through its various stages to the "adult" form of the laboratory culture with which the experiments were started. In this connection we wish to report that some of our cultures which have been obtained from the filtrates of various substances, after several months' culture in the laboratory, ferment sugar broths and give physiological tests in other media simulating those obtained with ordinary bacteria.

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DIAMAGNETISM IN METAL CRYSTALS

ONE of the fundamental problems in the study of the constitution of solid metals is to find the cause of the magnetic susceptibility due to crystalline state, which property is for most crystals very different from the atomic susceptibility of the metal. As an example tin (Sn) may be mentioned, which is diamagnetic in the liquid state, paramagnetic in the "white" (tetragonal), and diamagnetic in the "gray" (hexagonal) modification. Hence, one must conclude that the magnetic properties of a metal crystal depend mostly on an action caused by the coexistence of a number of molecules (atoms) in a given geometric configuration.

One fashion to approach this problem in a way which gives reliable measurements is the study of the magnetic susceptibility in anisotropic metal single crystals in different directions with regard to the crystal. After the magnetic constants of a pure crystal are known, a small number of atoms of another metal are added to the original substance, and a new single crystal of the same orientation is produced. For most of the measurements bismuth (Bi) was used, since its crystalline susceptibility is 15 to 20 times larger than its atomic magnetism; it is, furthermore, one of the most diamagnetic substances known.

The results obtained concerning the influence of foreign atoms on the magnetic properties of the crystal are the following:

(1) The presence of foreign atoms affects the magnetic properties of the crystal only if the atom goes into a solid solution. Inclosures or occlusion of heterogeneous substances do not affect the susceptibility. Thus, all metals which can not be dissolved in f. i. bismuth do not change its magnetic properties appreciably.

(2) If a soluble metal (Sn, Pb) is added in a quantity below the limit of saturation (which is very low—0.5 per cent. to 3 per cent.—for different enantiomorphous metals) the effect on the susceptibility is very large. Beyond the saturation the effect due to enclosures of eutectic mixtures is negligible.

(3) The effect of dissolved foreign atoms is surprisingly large and affects the crystal differently in different directions. (An atomic concentration of 1:10,000 alone changes the susceptibility several per-cent.)

(4) The influence calculated per added atom within the solubility limits in the crystal depends on their number, *i.e.*, the first few atoms have an effect which may be 100 fold larger than the atomic effect for larger concentrations.

(5) The dependence of the susceptibility of the crystal on the temperature is changed very much by foreign atoms such as to cause a large decrease with decreasing temperature. The decrease is different in different directions.

The effect mentioned under (3) works in all cases investigated as to *increase* the anisotropy of the crystal, *i.e.*, the ratio of the susceptibilities normal and parallel to the axis becomes larger due to the fact that the diamagnetism parallel to the axis decreases. This change is more distinct at lower temperatures, and it is thus possible *to obtain a crystal saturated with 3 per cent. Sn which is below 270° K. paramagnetic parallel to the axis and diamagnetic normal to it.* Since the x-ray analysis of such crystals does not show any difference from the normal Bi-crystal, it is evident that the atomic complexes within the lattice responsible for the diamagnetism must be of much larger sizes than the wave-lengths of the x-rays used.

To account for the exceedingly small amount of foreign atoms sufficient to influence the crystal diamagnetism it seems necessary to accept one of the two alternative conclusions:

(1) The distortion due to a foreign atom dissolved within the crystal lattice reaches very far (somewhat like 25 crystal-atoms in each direction.

(2) The foreign atoms are absorbed in discrete layers within the crystal, the total effect thus being due to an internal surface phenomenon.

The former assumption, of far-reaching influence in

[6] *Jour. Bact.*, 20, 25, 1930.
[7] SCIENCE, 74, 129 and 196, 1931.

dissolved atoms, can not be reconciled with the fact that no change in the lattice parameter can be detected by x-rays. It also contradicts the observation that the atomic influence decreases with increasing concentration of foreign atoms.

The latter conclusion seems to be more probable, since the formation of block-like complexes within a crystal produces large additional surfaces which absorb foreign atoms and thus form potential thresholds preventing the development of large free paths of electrons necessary for the crystal diamagnetism. It is obvious that the amount of foreign atoms necessary to form absorbed layers is many times smaller than the amount necessary for any volume-distortion. Furthermore, the change in internal surface conditions would scarcely be detectable by x-rays.

The size of these complexes calculated from the influence of foreign atoms comes out to be of the order of 1 micron (10^{-4} cm) and is in good agreement with the size observed microscopically by Goetz and is also in qualitative agreement with the theory of Zwicky of the secondary structure of crystals.

This picture of a crystal leads to certain predictions:

(1) The crystal diamagnetism should decrease as soon as the size of the crystal is less than the size of a crystal complex (secondary unit). (It was observed recently, first by Vaidyanathan, that colloidal particles of diamagnetic metals show smaller susceptibilities below a size of 1 micron.)

(2) The crystal diamagnetism should be influenced by any other change of the internal surface in the crystal. (The dependence of the diamagnetism of Cu on irreversible deformation was observed by Bitter, Lowance and Constant.)

(3) The electric conductivity—depending as well on the electric "transparency" of the crystal—should be affected the same way as the crystal diamagnetism. This was found true by Honda and his collaborators for the average susceptibilities on polycrystalline material.

It seems that the experiments described allow an insight into the constitution of a solid metal from a new angle; they also tie the crystal diamagnetism—a hithertofore isolated phenomenon—on to known electric qualities.

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Certain factors determining the direction of growth of nerve fibers: H. S. BURR (introduced by R. G. Harrison). A problem which has baffled students of the nervous system for many years is the determination of the factors which direct the growth of nerve cell processes and fix their termination. We do not know why olfactory nerves always end in olfactory centers. We do not know that motor neurones from the brain always end at the proper level of the spinal cord for the innervation of specific groups of muscles. These have been generally assumed. If they are true we need to know what factors in the nervous system and its environment bring them about. Several years ago while studying a related problem an amazing result appeared in a number of experimental conditions. Transplantation in Amblystoma of an additional olfactory organ adjacent to that of the host resulted in the outgrowth of an olfactory nerve from the transplant, which, instead of joining the olfactory nerve of the host, grew into the wall of the brain a considerable distance behind its normal termination. Not all olfactory fibers followed this course: some did run with those of the host into the forebrain, some followed the branches of nearby nerves to the skin, still others wandered blindly in the environing mesenchyme. These latter conditions can be explained partially on the basis of known facts, but the problem in which a new connection is established with the brain is not so easily solved. It is of fundamental importance that an adequate answer be reached, for the inherent implications are far-reaching. In the experimental condition we have a specific nerve establishing a new, different, one might almost say wrong connection in the brain. If such a thing is possible under experimental conditions it implies that the factors which bring it about are fundamental to the organization of the nervous system. Further, it implies that in given conditions neurones, instead of having their connections established according to a fixed pattern determined by the genetic history of the individual and its interplay with environment, may make contacts that are different and new. If this be true, then environmental circumstances, if they are of the proper sort, may alter the pattern of organization of the nervous system and thus profoundly affect behavior. What, then, are the environmental changes that bring about this new pathway of growth in olfactory neurones? An analysis of 175 experiments shows that conditions are right for the new connection in 29 cases. Of these 17 occurred after operations at one particular stage of development (Harrison stage 32). Furthermore, though outgrowth of olfactory fibers does not begin until five days after the stage of operation, at that time the wall of the brain is full of mitotic figures confined, however, to the relatively restricted area to which the nerve fibers eventually reach. Rapid cell division has been shown to be an index of high metabolic activity and the latter to be the head of a physiological gradient. In all probability this gradient, acting through the medium of a bioelectric field, attracts the growing olfactory nerves. These reach the area and, as has been shown elsewhere, stimulate the contained cells to continued cell division. An augmentation of the

gradient must then follow with profound effects upon all neurones in the field. The results of the experiments here presented are by no means conclusive, but they give definite clues as to the direction of continued research. At present all we can say is that our evidence suggests that areas of high metabolic activity are important elements in determining the organization of the nervous system. Factors, then, which stimulate or inhibit cell division could profoundly alter the pathways of neurones and hence the fundamental pattern of the nervous system with resulting changes in behavior. Such control is undoubtedly present normally in all vertebrates. Minor changes in the time relations of regulation may account for the development of amodal behavior in all forms but especially in man where the elaboration of the nervous system is greatest.

The developmental morphology of infant behavior pattern: ARNOLD GESELL (introduced by R. M. Yerkes). This paper reports methods and illustrative results of a systematic survey of behavior patterns throughout the first year of life. The survey has been in progress for five years and has been accomplished through coordinated studies by research members of the staff of the Yale Clinic of Child Development. The subjects were normal infants selected as to race, parentage and socio-economic factors. Twenty-five children have been examined at lunar month intervals from four weeks through fifty-six weeks of age. The infants were observed in a specially designed clinical crib under controlled conditions. The data cover the fields of posture, locomotion, prehension, manipulation, attentional regard, exploitive and adaptive behavior. The behavior of selected infants is being investigated in detail by photographic methods. By means of a photographic observatory equipped with a one-way-vision screen it has been possible to secure systematic cinema records of characteristic behavior at fourteen successive age levels. In experimentally controlled situations, like the prehension of a pellet or the exploitive manipulation of three cubes, the cinema proves an effective tool for the registration and analysis of behavior pattern. The cinema registers the sequence within a behavior episode; it chronicles the developmental changes in pattern at successive age levels; it preserves an authentic record which may be subjected to objective and comparative analysis. Each record incorporates its own time and space values which can be quantitatively expressed. Four feet of 16 mm film embody 160 frames, which depict 160 phases of a behavior episode, 10 seconds in duration. Repeating such a behavior situation at six advancing age levels yields a developmental record with over a thousand cinema frames or pattern phases. Cinema records aggregating 85,000 feet have been classified and catalogued by library methods. Specimens from the photographic records and from the analytic protocols will be shown to illustrate the use of cinematography in the charting of behavior forms. A special reel will show simultaneously in juxtaposition the behavior patterns of the selfsame infant in an identical situation at 24 and at 28 weeks of age, giving an immediate instantaneous view of a developmental increment. Structurally regarded, the behavior complex of the infant has a meaningful morphology, reflected in the developmental sequence and characteristic patterning of behavior forms. Ascertainable laws of growth are suggested by the underlying orderliness of these behavior forms and sequences. The cinema data in conjunction with the stenographic reports of the developmental examinations serve to define the increments and changing configurations of behavior growth. Systematically selected photographic records become the basis of an atlas delineating developmental trends. Using such records, we have begun the compilation of "A Photographic Atlas of Infant Behavior Patterns."

The vitamin B requirement: GEORGE R. COWGILL (introduced by L. B. Mendel).

A photometric survey of the nearer parts of the metagalactic system: HARLOW SHAPLEY and ADELAIDE AMES.

The natural history of the vibrato: CARL E. SEASHORE. This paper summarizes the present status of findings in an extended research program on the nature, the artistic legitimacy and significance, the variables, the evolution and development and the physiological basis of the vibrato in music and speech.

Modes of infection in poliomyelitis: SIMON FLEXNER. The recent epidemic of poliomyelitis has raised again the question of the modes of infection in the disease. This question is being studied with respect to verminous and human agencies of carriage of the virus and the portals through which it penetrates into the body to reach the central nervous system. The results of this study will be presented.

Genetic and histological studies on mouse leukemia: E. C. MACDOWELL and MAURICE N. RICHTER (introduced by C. B. Davenport). Each of two strains of pedigreed mice has attained a high degree of genetic homogeneity by continuous inbreeding under the same external conditions over a period of nine years. One of these strains is characterized by the regular occurrence of spontaneous leukemia in a high proportion of all the mice that survive the first six months; in the other strain no certain case of leukemia has been found. As already indicated by Slye's findings, these two strains demonstrate that spontaneous leukemia is under specific genetic control. The appearance of leukemia in the first hybrid generation (F_1) of a cross between these two strains proves that the genetic differential involved in the development of leukemia in one strain, and in its absence in the other, may produce leukemia in the heterozygous condition; that is, this differential is not a single recessive gene. The heterozygosity of the F_1 hybrids is manifest in a distinct reduction in the proportion of spontaneous cases as compared with the pure-bred susceptible strain—a situation that can not be interpreted in advance of further genetic analysis. The leukemia of any of these spontaneous cases can be transmitted to young mice of the susceptible strain by inoculations with suspensions

of splenic lymphocytes. By successive inoculations thereafter the leukemia can be transmitted indefinitely from mouse to mouse with virtually 100 per cent. susceptibility. In one of eleven lines of such inoculations the disease has been passed through 149 mice since leaving the mouse from which it arose spontaneously. The four lines of inoculations that have been carried for considerable periods agree in, (1) finding their requirements for susceptibility satisfied by mice of the susceptible strain, and also (2) by hybrids between the two strains, but (3) in no case in mice of the resistant strain; they also agree (4) in showing a marked increase in virulence during the course of the early transfers. On the other hand, the leukemias carried by these lines differ (1) in their requirements for susceptibility, as indicated by different proportions of susceptible mice in the same segregating generation following a cross between these two strains; (2) they differ in the interval before the culmination of the disease; (3) in the duration of the stage during which the mouse is obviously sick; (4) in the distribution of lesions as shown in gross autopsy as well as in the histological pictures—for example, in the appearance of a normal or enlarged spleen, and in the presence or absence of leukemic cells in the blood.

The active agent involved in these inoculations has power to reproduce itself indefinitely. It may exist in many subtle variations involving special affinities for infiltration of one or another organ or tissue. These various states may be maintained constant for long periods of time through many passages or they may change with relative frequency. If the living cell itself is not this agent, the existence of the agent is very closely dependent on the life of the cell, in that innumerable attempts to separate the living cell from such an agent have failed. The parallels between the situation in leukemia, in which both the spontaneous occurrence and susceptibility to inoculation are under the control of genetic factors, and the situation in such neoplasms as have been studied by Little, Strong and Bittner, are remarkably close and stand as evidence towards a final analysis of the nature of leukemia.

Liver edema as a reflex response to cold: HENRY G. BARBOUR (introduced by Y. Henderson). The onset of fever resembles the reaction of the body to cold. The shivering or "chill" produces extra heat, and this heat is saved by withdrawal of most of the surface circulation. That water is also lost from the blood has been shown for cold baths and many types of fever. What takes this water from the blood, and is this process significant for heat saving? Researches in collaboration with Messrs. H. T. Marshall and B. F. Aydelotte, of the University of Louisville, afford answers to both of these questions. We have shown that fever poisons (cocaine, beta-tetrahydronaphthylamine, foreign serum in a sensitized animal) while concentrating the blood increase to about the same extent the water content of the liver. We have found the liver water similarly increased in "cold" fever, which is produced by direct application of cold to the thermostatic region of the rabbit's brain. Microscopic sections of such livers show the cells swollen with water at the expense of the canals which drain the liver. But after the sympathetic nerves to the liver are cut, the rabbit's blood no longer becomes concentrated when the brain is cooled. Further, a normal dog subjected to cold baths yielded an average serum specific gravity increase of .0035. The same animal after liver denervation showed an average specific gravity increase of only .0012. This would indicate that the liver takes up two thirds of the lost blood water. Small samples of two dogs' livers were also removed under local anesthesia, with the animal at complete rest. Before applying icepacks to the chest and thighs the respective livers contained 71.8 per cent. and 72.4 per cent. of water. After about one half hour of such chilling the same livers contained 73.7 per cent. and 73.1 per cent. It seems apparent that by a reflex response to cold, acting through the brain, the liver is induced to take up water. In the last experiment cited the liver glycogen fell from 2.8 per cent. to 2.1 per cent., a well-known phenomenon which tends to create a demand for water by increasing the osmotic pressure. How does removal of water from the blood to the liver save heat? Whenever extra heat is produced, if the body is to retain a normal temperature extra heat loss is demanded. A familiar instance is exercise. Here the demand for heat loss is met largely by the pouring out of water for evaporation on the body surface—sweat in man, saliva in the dog and extra water loss through the lungs and skin of mammals in general. In five rabbits we have carefully followed the water loss in the onset of cocaine fever. It is very striking that during the first half hour of temperature rise the water loss shows no significant increase. It actually decreased in two of our experiments. This lag occurs while the liver is taking up water and the blood is concentrating. Evidently the liver can thus retard surface evaporation and delay the onset of sweating. Later on, the fever temperature being established, the water loss may be doubled or trebled. The water loss from the body then seems to keep pace with that from the liver, for an average rabbit with cocaine fever loses by evaporation 3 or 4 cc extra water per hour. This is just the rate at which the liver releases its extra water, as shown by determinations from animals killed in the various stages of fever. Thus the liver plays a significant rôle in the mechanism by which the body saves heat in response to cold or in the onset of fever.

Organs capable of producing acetone substances. H. E. HIMWICH. Muscle of the normal mammal oxidizes both fat and carbohydrate, the latter in the form of sugar. Since insulin is needed for the oxidation of sugar, muscle of the diabetic animal burns fat only. On the other hand, the character of oxidations in the brain is unchanged by diabetes, since the brain, which utilizes carbohydrate exclusively, transforms sugar to lactic acid before oxidation and lactic acid is oxidized without the aid of insulin. Unless carbohydrate and fat are oxidized simultaneously, fat can not be completely burned and toxic end-products, the acetone substances, accumulate.

Thus only organs which oxidize both fat and carbohydrate, the latter in the form of sugar, are capable of producing acetone bodies during diabetes.

The relationship between chemical composition and taste: ARTHUR L. FOX (introduced by A. F. Blakeslee). In working with phenyl thio carbamide an accidental discovery disclosed the fact that this compound is tasteless to certain individuals, while to others it is extremely bitter. As slight alterations in chemical structure often cause great changes in physical or physiological properties it was considered of interest to determine whether this property existed in other related compounds. Therefore a large number of related mono aryl thio carbamides were investigated, and most of them were shown to possess the same property. Then symmetrical di aryl thio carbamides were studied and were also shown to possess similar physiological action. Various other thio carbamides were studied, but in almost every instance the same result was obtained. So far only two compounds have been found which deviate from the class to which they belong, but this deviation is believed to be due to insolubility.

Genetics of sensory thresholds:—taste for phenyl thio carbamide: ALBERT F. BLAKESLEE. Dr. A. L. Fox first showed that many people can not detect the bitter taste in crystals of phenyl thio carbamide. In an earlier publication, Salmon and I showed that taste deficiency for the crystals appears to be inherited as a Mendelian recessive. (The same conclusion has been reached independently by L. H. Snyder). In addition to "non-tasters" of the crystals, we were able to classify the "tasters" of the crystals roughly according to their taste acuity by means of dilutions at which the bitter taste was first detected. This work on taste thresholds has been extended. Thresholds for the "tasters" have been established from 1: 500,000 to 1: 5,000 dilutions. These extreme thresholds are rare. The commonest threshold is at about 1: 80,000. With a few possible exceptions, none could taste the pure crystals who could not taste bitterness in a dilution of 1: 5,000. Tests of thresholds in about 100 families indicate that acuteness of taste for the chemical is inherited, since there is an obvious correlation between the thresholds of parents and children. It has been the practice to test people with the dry crystals if they could not detect bitterness in a 1: 5,000 solution and to classify them as "non-tasters" if they did not report the crystals as bitter. It is now found that phenyl thio carbamide is also bitter to "non-tasters" for the crystals if the chemical can only be gotten to their sense organs in a sufficiently concentrated form. Most "non-tasters" can detect bitterness if a cold saturated solution is used. The few who are still negative to this test have been found to taste bitterness in a saturated solution in hot water or still better in hot weak alcohol. Many who could detect bitterness in relatively weak solutions were unable to taste the pure crystals, but, so far as retested with saturated solutions, they were found to react positively. Inability to taste the crystals may have something to do with differences in salivas as well as to differences in sense organs. A few could not detect bitterness in phenyl thio carbamide solutions but reported a different taste. Some said it was sour, some called it peppery and others described it as astringent like alum. There is evidence that a condition analogous to color blindness exists in regard to taste in that two substances which taste differently to most give to some the same sensory reaction. Thus two persons, who were given a special test, were unable to distinguish quinine from hydrochloric acid. Some tasted bitterness in weak concentrations but could perceive little difference between the various test solutions, each of which was four times as strong as the one previously tasted. Others showed reactions corresponding to the relative strengths of the solutions. There was no close relation between emotional response and threshold at which the taste was first perceived. Taste acuity for phenyl thio carbamide was found to have no close relation to taste acuity for other bitter compounds —picric acid and quinine sulphate—which also afford a wide range of thresholds. Likewise there was no close relation found with acuteness of taste for an acid and for a sweet. Differences in taste thresholds for a number of other substances have been found by us and other investigators. The same is true for odors. In the single case investigated we have found these differences in powers of sensory perceptions innate and hereditary. Evidence is thus given for the belief that humans are born with innate differences in respect to all their senses and that different people live in different worlds, therefore, so far as their sensory reactions are concerned.

Glucoside formation in methylated glucoses: P. A. LEVENE and A. L. RAYMOND. The ring structures of the γ- and normal glucosides of the fully methylated sugars have been established beyond dispute, whereas those of the non-substituted sugars have continued to be a matter of discussion. The structure of the normal glucosides of the non-substituted sugars has recently been demonstrated to be that of a pyranose so that there remained for consideration only the γ-glucosides of the non-substituted sugars. For these the butylene and propylene oxidic structures are under consideration. To choose between these two possibilities, a study has been made of a 3-monomethyl and a 4-monomethyl sugar as regards their glucoside formation. It was found that while the 3-methyl sugar gave two glucosides, a normal and a typically γ-, the 4-methyl gave only a normal glucoside. This would seem definitely to exclude the propylene oxide structure and favor the assignment of the butylene oxide structure to the γ-glucosides. In support of this view is the fact that the rate of glucoside formation in the case of the 4-methyl sugar is similar to that of tetramethylglucopyranose, which has only position 5 unsubstituted.

Artificial hormone substances: TREAT B. JOHNSON. The synthetic organic chemist is very much interested in the study and preparation of artificial substances which may prove to be of practical value in the prevention and cure of diseases. He is very desirous of

utilizing the resources of his science in every way possible for the benefit of mankind. Both the animal and plant are productive in their growth of active principles which exert a pronounced physiological action when liberated in the living organism, and their separation and utilization by man has contributed greatly to the advancement of almost every field of medicine. We have adopted the materials that nature provides for us, and we have also gone further and modified these materials, purified them, and have been extremely successful in making many new combinations of great medical value. We are now advancing to the third stage of this program in the development of drugs for the use of man, and it is the organic chemist who now seeks to duplicate further the natural products to produce new organic derivatives from them and to prepare in his laboratory entirely new compounds related structurally to the natural substances and finally to create artificial materials which may serve as practical substitutes for nature's products. Among the many substances formed in the animal metabolism are the glandular secretions which our physiologists have designated by the general term, "hormones." These interesting products are secreted in animal economy in extremely small quantities, but they are very powerful in their physiological action, and it is known that an animal can not live and grow without their aid. These active substances serve in animal metabolism as chemical messengers, so to speak, and they exercise a very fundamental part in regulating all the normal life processes. In other words, without the proper functioning of these glandular organisms which produce these secretions, man can not live. Thyroxine and adrenaline are two important representative organic substances which are found in the secretions of special glands, and they represent two of the most important substances which we classify under the term "hormones." It is an interesting fact that the structures of both of these substances have been established, and the chemist has been able to prepare both of them artificially. We are, therefore, now able to produce two of these important hormone principles in our laboratories, and are therefore not dependent for their supply on natural materials. It is an interesting fact that, as a result of advanced research by the organic chemist, absolutely new organic constructions can be synthesized which show almost the same physiological activity of many of these hormone principles which nature provides for her service. When substances of this type are obtained by the organic chemist, their structure established and their physiological activity shown to duplicate the materials found in nature, they are spoken of as artificial hormones. The substances discussed in this paper belong to this class of compounds. They represent new compounds which have never been prepared before and have been found to show a physiological activity which duplicates that of natural hormones of certain types, and therefore are of extreme interest to the chemist and call for an exhaustive study. There is a great probability that some of these organic combinations will be found to be perfect substitutes for natural hormone compounds and lead to products which are far superior in their physiological activity to those already produced by nature. The field of investigation is a most inviting one to the chemist, and the thiazol compounds which have been chosen as a group of compounds deserving of chemical attention offer possibilities of synthesis which are not common to many classes which the chemist can select for his work. It is possible to prepare, in the series under investigation, compounds, for example, that are far less toxic than the natural hormone—adrenaline—and still retain a physiological activity that promises a possibility of very practical application in medicine. This work has been in operation in the Sterling Laboratory for the past four years, and a program of work has been mapped out which will keep certain members of the staff occupied in this field for a long time.

The influence of complex salt formation on the electronic structure of iron oxides: OSKAR BAUDISCH (introduced by T. B. Johnson).

Further studies of rate of growth of albino rats: ARTHUR H. SMITH and W. E. ANDERSON (introduced by L. B. Mendel).

The Arizona expedition for the study of meteors: HARLOW SHAPLEY, E. J. OPIK and S. L. BOOTHROYD.

The adequacy of ocular compensation to bodily rotation: G. R. WENDT (introduced by Raymond Dodge). Graphs will be shown (by lantern slides) which show the relationship between the velocity of the slow phase of vestibular nystagmus and the velocity of bodily rotation. Using normal college students as subjects, and photographically recording eye-movements through closed eyes by the Dodge mirror recorders it has been found that in the simple conditions of rotation used in this experiment ((1) translation through 65 degrees in two seconds, (2) harmonic oscillation through 15 degrees) the velocity of compensatory eye-movements bears a constant relation to the angular velocity of rotation. The velocity of the eyes at any moment is found to vary directly with the velocity of the head. Related to earlier work by Dodge, his collaborators and others, it will be pointed out that these results make definitively untenable the notion that vestibular stimulation operates on the reflexes by acceleration alone. In these experiments the response of the eyes is not related to acceleration but to velocity.

(*To be concluded*)

BOOKS RECEIVED

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